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ABSTRACT

New analytic procedures are presented for determining the relationship between students' experience in classrooms and learning curriculum content. Based on data obtained from two studies in the Understanding Learning and Teaching Project (ULTP) conducted at the University of Canterbury (New Zealand), an analysis of the multi-layered nature of student classroom experience is conducted. In addition, a model of learning and schema construction is developed which predicts student learning of each test item. Four dimensions of classroom experience are emphasized: knowledge and skill acquisition, task accomplishment, personal development and interpersonal interaction, and cultural processes. The prediction procedures involve using data from observations and recordings of public and private behaviors and utterances of selected case study students. The model and analytic procedures accurately predict 83% of the outcomes of individual test items. The nature of the learning processes implied by the model and the implications for understanding effective teaching are discussed. Nine tables, one figure, and six flowcharts are included. Appendices include the design of the four studies in the ULTP, sample item files from the two studies, guidelines for coding the content of student responses, rules for predicting learning outcomes from the information stream, functional classifications of student behaviors, and validity coding categories. (TJH)

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MAKING THE CONNECTION BETWEEN TEACHING AND LEARNING

Determining How Pupils Learn from the Information They are Exposed to in the Classroom

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Paper presented at the Annual Meeting of the American Educational Research Association, Chicago, April 1991

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Abstract

This paper reports the development of new analysis procedures for determining the relationship between pupil experience in classrooms and their learning of curriculum content. Based on the data obtained from two of the studies in the *Understanding Learning and Teaching Project* an analysis of the multi-layered nature of pupil classroom experience is carried out and a model of learning and schema construction is develcped which is used to predict each pupil's learning of each outcome test item. These prediction procedures involve using data from detailed continuous observations and recordings of the public and private behaviours and utterances of selected case study pupils. Using the model and analysis procedures accurately predicted 83% of the outcomes of individual test items. The nature of the learning processes implied by the model and their implications for understanding effective teaching are discussed.

1. *Introduction*

> *Those who have treated the sciences are either empirics or rationalists. The empirics, like ants, lay up stores, and use them; the rationalists, like spiders, spin webs out of themselves; but the bee takes the middle course, gathering up her matter from the flowers of the field and garden, and digesting it and preparing it by her native powers.*
>
> Francis Bacon, *Novum Organum* (1620)

Maxima debetur puero reverentia. Juvenal

This paper is concerned with understanding how pupils learn in classrooms. It reports some of the results of the Understanding Learning and Teaching Project being carried out at the University of Canterbury. This project has been guided by the belief that understanding effective teaching, and providing the kind of knowledge which teachers need in order to be more effective, can only come from knowing how teaching affects the way pupils learn in classrooms. For this reason the project has been designed to obtain detailed obsérvational and recorded data on the classroom experience and learning of individual pupils in a variety of classrooms, and to develop from this data an understanding of the cognitive, social, and cultural processes that determine learning.

The basic design of each of the four studies that have been carried out in the project is set out in Appendix A. The failure of previous studies of classroom teaching and learning to obtain consistent results s[illegible]ested that there was a need to obtain much more comprehensive da[illegible]on the experience of individual pupils over longer periods of time. The data obtained for the studies in the Understanding Learning and Teaching Project involved using procedures (such as one observer per child and individual broadcast microphones) designed to record, from several parallel sources, as much as possible of the continuous experience of selected case study pupils (representing gender, race and ability differences) through self-contained curriculum units.

The first stage of our analysis was to collate all the data from all sources and to break it up into quarter minute intervals. We then created 'item files' by bringing together every aspect of a pupil's experience relevant to a specific outcome test item into a single file. These item files provided the basis for analyzing the relationship of pupil experiences to the learning of specific test-item defined curriculum content. Appendix B contains examples of some of these item files, simplified and abbreviated for this paper.

Preliminary results using a combination of quantitative and qualitative analysis procedures on these item files have already been reported (Alton-Lee, 1984; Alton-Lee & Nuthall, 1990; Nuthall & Alton-Lee, 1990,

Understanding Learning and Teaching Project: Study Three, 1990). However, we have found as we have proceeded with the analysis of our data that traditional quantitative procedures (e.g. coding, counting, and comparing frequencies of behaviours associated with items learned and items not learned) were not producing consistent interpretable results and were not adequate to handle the complexity and variety of the data. Nor were we willing to settle for unstructured qualitative analyses (although we have used qualitative analyses on some aspects of our data, cf. Alton-Lee, Nuthall & Patrick,1987). Hence we decided to try to develop new analysis procedures that incorporated important elements of both the quantitative and qualitative traditions but reflected the richness and depth of our data (as in Gage's 'second version' of the 'aftermath of the paradigm wars', Gage 1989).[1]

2. *The Significance of Context and Function in Analyzing Pupil Experience*

We began the search for new analysis procedures by trying to identify and focus on aspects of the data that were not being adequately dealt with by the quantitative analysis procedures. The first of these was the failure of the standard coding and counting procedures to handle the major role that context seemed to play in influencing pupil experience in the classroom.
The standard quantitative procedures involve breaking up experience into precisely defined and countable events or behaviours. These procedures ignore the fact that these events or behaviours are embedded in a temporal context or sequence and are normally perceived as an integral part of that context. For example, if a teacher says something to a pupil, and then repeats the same statement in the same words some time later, the second statement is not experienced by the pupil in the same way as the first statement. The words, tone of voice, etc., may fit the same descriptive definition and be coded by an observer as two occurrences of the same behaviour, but because the second statement is a repetition it does not convey the same information to the pupil as the first statement.

The significance of context is well established in other fields of research. Linguists have established that the meaning of words and phrases is determined in large part by the linguistic and social context in which they occur. Information theory is based on the premise that the information value of signals is a function of the context in which they occur. Even in behaviour analysis research (which depends on dividing behaviour up into discrete, countable behaviours) the methods of analysis used focus on the temporal sequence of events. Respondent behaviours are controlled and shaped by *contingent* events. Single-subject designs, of the kind favoured by behaviour analysts, use temporal patterning to determine the significance of behavioural interventions.

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[1] A full account of the development of these new procedures and the rationale behind them has been reported in Nuthall & Alton-Lee, 1991

Central to the idea of context in the classroom is the idea of a stream of experience occurring through time for each pupil. The events and activities that occur in the classroom must take their primary significance from their temporal location in this stream of experience.

Closely related to the idea of context is the idea of function. Consider, for example, a classroom in which the teacher has instructed the pupils to read a worksheet and answer the questions printed on it. In that context, a pupil who is reading the worksheet carefully is (presumably) interacting with the information contained in the worksheet. Contrast that with an occasion in which the teacher is standing in front of the class and talking to pupils about what they need to do to complete an assignment for homework. During the time the teacher is talking the pupil is fully absorbed in reading a worksheet. On this second occasion, the pupil's reading behaviour interferes with the pupil hearing the teacher's instructions. On both these occasions, the pupil's behaviour would be coded by an observer (using well-defined descriptive behaviour categories) as the same behaviour. In a descriptive sense, it is identical behaviour. However, from the point of view of acquiring task relevant information, the reading behaviour functions in quite different ways on the two occasions.

If the functional role of behaviours is taken seriously, this raises the question of the kinds of functions that classroom behaviours can have. How can they be identified and how many are worth considering?

3. *Identifying the Dimensions of Classroom Experience*

As a way of guiding our initial identification of the functions that might be useful to our analysis, we defined a 'function' as the role that a behaviour or activity plays in relation to an identifiable classroom learning process. In this definition, 'learning process' is intended to include all the kinds of changes (in knowledge, skills, self-concept, attitudes, beliefs, etc.) that are of interest to educators.

With the type of data we have obtained for the Learning and Teaching Project, the most clearly documented dimension is the *knowledge and skill acquisition* dimension. At the beginning of a unit of study (at the time of the pretest) the pupil has limited knowledge of the content of the unit. Through the unit, the pupil is exposed to a sequence of information and experience. If the pupil learns from this information and experience, she/he ends up with the knowledge and skills that were the intended outcome of the unit. Each pupil behaviour or experience plays a role in a cumulative knowledge and skill acquisition process.

Our data suggested that there are three further dimensions to the classroom that need to be to be identified and analyzed in order to understand children's classroom experience. These are:

the task accomplishment dimension: knowing what is required by the teacher and how to engage in lessons and carry out and complete set tasks,

the personal development and interpersonal interaction dimension: the development of the pupils' sense of self, their interests, motivations and relationships with each other and with the teacher, and

the cultural process dimension: the development of cultural role and identity, being female or male, non-white or white, working class or non-working class.

4. The Four Dimensions of Classroom Experience

4.1 Knowledge and Skill Acquisition

The processes of knowledge and skill acquisition have been briefly described above. It is assumed that during the course of a unit of work, the pupil moves from a state of limited knowledge or skill to a state of greater knowledge or skill as a consequence of the information the child is exposed to and the experiences the child has during the course of the unit. The processes involved are primarily cognitive. They involve information processing, acquiring and remembering information, developing cognitive and practical skills. Most of the information processing and knowledge acquisition processes involved in this dimension are hidden from the teacher because they take place in the mind of the pupil. Their state or progress can only be inferred indirectly from how pupils respond and perform in class tasks.

4.2. Task Accomplishment.

The explicit activities of the classroom take place within a system of rules and are guided by task-specific instructions. Pupils learn the rules and rituals of academic activity. For example, they learn to look interested and listen when the teacher is talking, to write neatly and underline the headings in their written assignments. Their academic work is frequently broken up into tasks, each of which has it own set of instructions and rules for successful completion. At the beginning of the school year and at the beginning of each new task, the pupils must learn the new set of requirements. During the course of a task they must make sure that they are following instructions and obeying any explicit or implicit rules associated with the task. Sometimes the rules or expectations are implicit or ambiguous and pupils must learn to be sensitive to the existence of such expectations and know how to identify exactly what they are.

This dimension is separated from the knowledge acquisition dimension because the two are only indirectly connected to each other. Usually a teacher will design or set up a task with the intention that the pupils will learn from the experiences generated by carrying out the task. However, this is not always the case. Pupils may carry out tasks in ways not intended by the teacher and learn from the experience, or they may carry a task out as intended but not learn from it.

While the processes involved in knowledge acquisition are cognitive and largely hidden, the accomplishment of tasks is usually visible to an observer. It results in the production of a written assignment, the completion of a worksheet, written answers to a set of exercises, or a carefully coloured diagram. At the level of specific classroom rules, it results in the pupils sitting up straight in their chairs, listening attentively to the discussion, or putting their equipment away in the right place.

4.3. Personal Development and Interpersonal Interaction

The third dimension is concerned with the way in which teacher and pupils get on with each other as persons. It is concerned with the ways in which social interaction constructs and modifies personality, and with the ways in which that social interaction takes place. It is about getting on together, about liking and disliking, about dominating and being submissive, about being helpful or antagonistic, confident, cooperative, secure, afraid, capable, about enjoying or not enjoying the classroom experience, and about coming to like or dislike curriculum topics.

This is the dimension that teachers focus on when they say that they want their classrooms to be happy places where the pupils feel secure and learn to enjoy being at school.

The processes occurring in this dimension are partly visible and partly invisible to the teacher, depending on how sensitive the teacher is to the nature of interpersonal interactions. Signs of these processes are evident in the looks on the children's faces, in the frowns and smiles and signs of eagerness, boredom or antagonism, as well as in their interactions with other pupils and the teacher.

4.4. Cultural Processes

Underlying the personal development and interpersonal interaction dimension is another dimension in which the larger social structures of the society are played out. Teachers may be very aware of the quality of their personal interactions with their pupils, but they may, at the same time, be completely unaware of the gender or racial imbalance that exists in those same interactions. Cultural practices and roles are generally enacted without

awareness by the participants in that culture. Culture consists largely of what is taken for granted in a society; what is done without thinking. This lack of awareness of the nature of culturally defined roles and practices suggests the cultural process dimension of the classroom needs to be defined and analyzed separately from the personal development and interpersonal interaction dimension.

Identifying cultural process as a dimension implies that culture is learned in the classroom. It implies that the classroom is an arena in which processes relevant to a hidden cultural curriculum operate. These processes involve learning culturally defined roles, patterns of behaviour, and beliefs, that are more general than those located in the *task accomplishment* function. They involve learning to become a culturally acceptable member of the larger society. An analysis of the gender and race dimension of cultural learning in the classrooms in our studies has been reported in Alton-Lee, Nuthall & Densem (1991).

The four dimensions which have been described above have been identified for the purposes of defining the different functional roles which behaviours and events in the classroom might play. They have been identified in answer to the question: What are the major outcomes that classroom experiences lead to? Distinguishing different dimensions is a first step in the process of clarifying how classroom experience affects pupils. These dimensions do not, in fact, operate independently of each other. What is taking place in one dimension has significant effects on what is taking place in other dimensions. For example, the changes taking place in a pupil's sense of self-worth as a consequence of interpersonal interactions occurring in the classroom will affect the way the pupil engages in task activities. A pupil's success in acquiring relevant knowledge will affect how that pupil interacts with other pupils.

5. The New Analysis Procedures: Preliminary Theoretical Assumptions

In the remainder of this paper we will describe the development of procedures for analyzing the knowledge and skill dimension of classroom experience, and the results of using these procedures to predict and understand how the pupils in two of our studies learned, or did not learn, from their classroom experience.

In developing appropriate analysis procedures for understanding the knowledge and skill acquisition dimension it was presumed that class discussions and activities produced for each pupil a stream of information (propositions, descriptions, examples, reasons, etc.) from which the pupil might acquire knowledge, either by constructing new knowledge or beliefs or by modifying or replacing existing knowledge or beliefs. The pupil's

construction or reconstruction of knowledge involves an interaction between this stream of information and what the pupil already knows and believes. This interaction is a continuous process resulting from the pupil's attempts to carry out the tasks and activities required by the teacher, and from the pupil's own need to make sense of experience (See Figure 1)

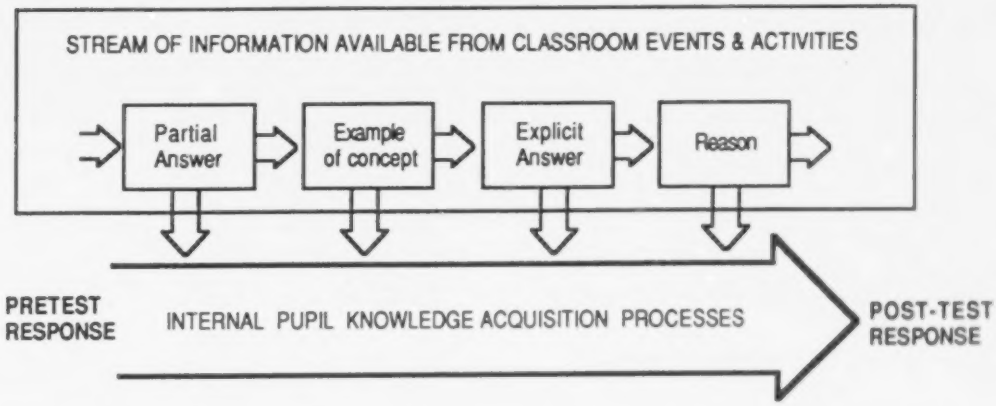

Figure 1. The stream of information and the pupil's knowledge acquisition processes.

Understanding the cognitive processing that the pupil is engaged in at any one time requires examining not only the classroom events occurring at that time, but also the events that led up to that particular time. The pupil's short term memory holds recent events and processes in mind so that they are also part of the pupil's experience at any one time.

As the pupil experiences more and more information, the quantity and quality of the resulting knowledge is likely to be greater. However, in the normal course of classroom activities, the flow of information does not move in an orderly fashion from topic to topic. Information central to one topic is interspersed with information which is either centrally or peripherally related to other topics. The way information relevant to different topics or test items is likely to be experienced by a pupil through the course of class discussion and activities is represented diagrammatically in Figure 2. In addition to this temporal interspersing of information, the same quarter minute of class time may contain information which is relevant to several different test items simultaneously. An example of such a quarter minute interval from Study Three is set out in Figure 3, with a description of the relevant items listed below the transcript of the quarter minute.

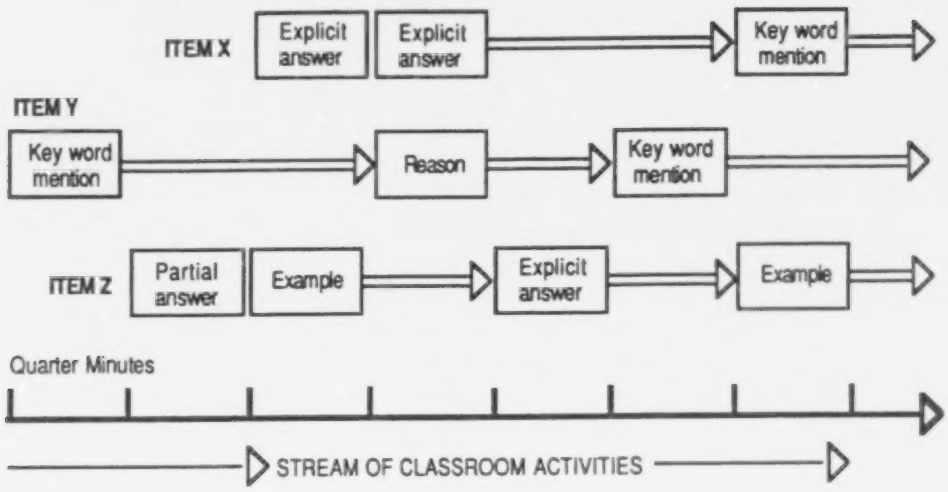

Figure 2. The item relevance of information available to pupils during classroom activities.

Acquiring knowledge from the stream of information relevant to a particular item presents two problems for the pupil. First, if a piece of information is followed by a long gap, that information may be forgotten before subsequent information becomes available and can be integrated with it. The cumulative effect of the stream of information depends on the pupil's ability to hold incoming information in mind (and keep it separate from other incoming information) long enough so that subsequent item-relevant information can be integrated or processed with it.[2]

The second problem for the pupil is that the information is sometimes incomplete or relatively uninformative. It is information which is useful to the pupil only if the pupil already has important item-relevant knowledge. In the example of a quarter-minute of discussion reproduced in Figure 3, the information that Puerto Ricans speak Spanish is only helpful to a pupil in answering a test-item on the language most commonly spoken in Central America (Item #25) if the pupil already knows that Puerto Rica is in Central America. If the pupil never learns that Puerto Rica is in Central America, or is told but forgets, the information that Spanish is the language of Puerto Ricans is of no use for answering that test item.

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2 The process of integrating related information when it is experienced inter-leaved with other information was first identified and studied by Bransford & Franks (1971)

Transcript of quarter minute of class discussion

(Study Three, Day 4, Time 281. The teacher is discussing a story about a Puerto Rican boy who lives in New York)

T: I think it would be a language problem where he (Puerto Rican boy) may speak a different language. What language do Puerto Ricans mainly speak? You've read it already in your notes.
P: Spanish
T: Spanish. And when they go to a new city, they keep their own customs, and language, and yet if you go to school in New York you have to speak English ...

Items Covered in this Quarter Minute

18. New York is made up of? People of many races. (Puerto Ricans are an example of one of several races living in New York. Code 6, 3.4)

21. Immigrants are? People who come to live in a new country. (Puerto Ricans are an example of a group of people who have come to live in New York. Code 6, 3.4)

25. Most of the people who live in Central America speak? Spanish (Part of an answer; pupils also need to know that Puerto Ricans come from Central America. Code 5, 2.3)

46. Most of the new immigrants coming to live in New York in the last few years have come from? Mexico and Puerto Rica. (Additional information about Puerto Ricans who have already been identified as recent immigrants. Code 7, 3.2)

50. What do you think is the most important reason why a Puerto Rican boy living in New York would get very low marks in school? He would not understand much English. (Information from which the answer can be inferred. Code 5, 2.1)

907. Are the following found in New York? In Christchurch? In neither? In both? 'Many people speaking Spanish' (Part of an answer; pupils also need to know whether people in Christchurch speak Spanish. Code 5, 2.3)

Figure 3. An example of a quarter-minute of class discussion containing information relevant to several items[3]

[3] Codes referred to in the descriptions of the items are the codes used to classify the nature of the content that pupils are exposed to. They are described in Appendix D.

Another way of describing these problems is to say that the child needs to be exposed to sufficient item-relevant information within a short period of time in order to engage in the process of constructing an item-relevant schema. This schema can, in turn, be used for interpreting, structuring and storing further incoming information. If the initial information is too spread out in time, parts of it will be forgotten before an appropriate schema can be constructed.

Before an item-relevant schema is formed, incoming information will remain dispersed or remain disconnected and unretrievable in the child's memory. The construction of an item-relevant schema provides the mechanism for retrieving relevant information from memory at the time of a recall test. It acts as the focus of the knowledge integration and elaboration processes necessary for the development of the pupil's knowledge.

As a basic rule, the information needed to construct a schema consists of the answer to the item and additional related information such as examples, analogies, reasons and relationships between item-specific concepts and other significant concepts. Alternatively, an adequate schema can be formed from several pieces of incomplete answer information or from sets of examples which collectively contain sufficient information from which the pupil can deduce (discover) the item answer.

6. The Steps That Make Up the Analysis Procedures

We have developed six steps to determine, from the recorded data, if, when, and how a pupil acquires the knowledge needed to answer a specific test item. These steps are:

A. Identify the knowledge that is needed by identifying the type of item to be answered.

B. Identify the item-relevant knowledge and beliefs that the pupil starts the unit with.

C. Identify the content of the stream of information, relevant to the item, which the pupil is exposed to.

D. Identify how each pupil is interacting with each piece of information and tag it accordingly.

E. Determine if and when an item-relevant schema is formed by applying the knowledge acquisition rules (Appendix D) to the tagged stream of information.

F. Validate the cognitive processing (schema construction) identified in Step E by examining the parallel pupil utterance and behaviour data.

The analysis procedure set out in these steps implies a specific set of relationships between recorded data and underlying cognitive processes. The nature of these relationships has been depicted in Figure 4. The content and behaviour data analyzed in Steps C and D are shown in the top half of the figure. The effect of the content which a pupil is exposed to is mediated by the behaviours the pupil is engaging in at the time. The prior knowledge and beliefs on the left of the figure are identified from interview and pretest data in Step B. They are depicted as the starting point for subsequent cognitive processing. Step E involves identifying the pupil's cognitive learning processes, including schema construction, and predicting the consequent outcome test performance. The utterance and behaviour data used in Step F to confirm and validate the pupil's cognitive processing is depicted in the bottom half of the figure. These utterances and behaviours are treated as symptoms or expressions of underlying cognitive processing.

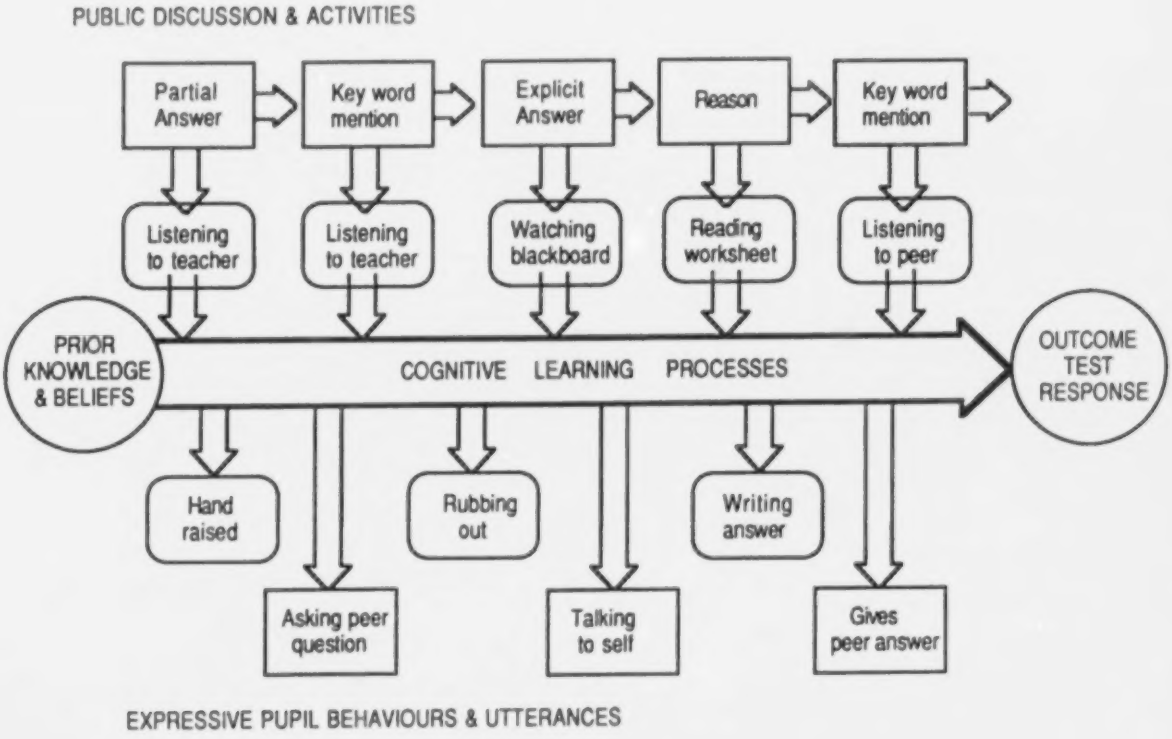

Figure 4. Model of the process-variable relationships implied in the analysis procedures

7. Using the Analysis Procedures: Identifying the Stream of Information (Step C)[4]

To illustrate the application of these procedures we will begin with an example of identifying, from an item-file, the stream of item-relevant information that a pupil is exposed to. This example, taken from Study Three, concerns the way a pupil (Jon) learned the answer to an item involving a specific piece of information (that Puerto Rica is an island in the Caribbean Sea). The wording of the test item and the detailed transcripts and records of each pupil's experience of the content of that item are contained in Appendix B.1.

The Stream of Information for Jon

The creation of the original item-files involves the identification of each quarter minute of class time during which there was some information relevant to the item. The following is a brief summary of the stream of information contained in the item file for item #16 that Jon was exposed to.

Day 1, Time 169	Jon and peer are looking at atlas map of North America. Peer identifies Caribbean Sea.
Day 2, Times 89,90	Teacher displays diagram on OHP which indicates Puerto Ricans come from a Caribbean island. Teacher-peer discussion informs that Puerto Rica is an island in the Caribbean. Teacher reads statement on OHP that Puerto Ricans speak Spanish, have 'neat' music.
Day 3, Time 11	Pupil asks if teacher will say where Puerto Rica is (question not answered)
Day 3, Time 81	Jon reads worksheet statement: Puerto Rica is a Caribbean island associated with the United States.
Day 4, Time 22	Teacher asks group (including Jon) where Puerto Rica is. Peer says it is near Mexico in the Caribbean. Teacher confirms it is in the Caribbean Sea.
Day 4, Times 30,31	Teacher points out the location of Puerto Rica on sketch map of North America drawn on blackboard. Teacher says: Puerto Rica ... is an island here (pointing to map)
Day 4, Time 196	Teacher says that the boy in a story read by pupils is a Puerto Rican boy 'which means that he comes from Puerto Rica'.

The relevant content of each quarter minutes is then coded using the content coding scheme reported in Appendix C. The coding of the stream of

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[4] It is easier, in order to simplify the illustration of the analysis procedures, to begin at the third rather than the first step. Beginning at the third step involves ignoring, in the meantime, the pupil's prior knowledge, and assuming that the pupil is actively involved in making use of all the information to which she/he is exposed.

information for this item is set out in Table 1. The information experienced by the other pupils has also been set out in Table 1 for comparison.

Table 1. Summary of Content Sequences for Each Child for Item#6 (Study Three)

		CODED CONTENT[5]				
Day	Time[6]	JON (Source)	JOE	ANN	MIA	Context
1	169	8 (atlas map)				Individual Task
2	89	5 (transparency)	5	5	5	Whole-class
	90	1 (teacher)	1	1	1	Whole-class
	90	7 (teacher)	7	7	7	Whole-class
3	11	7 (pupil)	7	7	7	Whole-class
	81	1 (worksheet)		1		Individual Task
	90		1			Individual Task
	121				1	Individual Task
4	22	1 (tcher & pupil)	1	1		Part-class group
	30	5 (tcher & map)	5	5	5	Part-class group
	31	10 (teacher)	10	10	10	Part-class group
	194				10	Part-class group
	196	10 (teacher)			10	Part-class group
	200				10	Part-class group
	202				8	Part-class group
Test Item Outcome[7]		L & R	L & F	N-L	L & R	

For Jon, the information he was exposed to about the location of Puerto Rica was spread over four days and came from an atlas map, a teacher statement, a statement read in a worksheet, teacher-pupil discussion, and a sketch map on the blackboard. On three occasions, the information was a verbal statement of the answer to the question (Code 1, Day 2/90, 3/81, 4/22). Before, during and after one of these occasions (Day 2/89), part of the answer was visible on an overhead transparency (Code 5). On a previous occasion (Day 1/169) Jon came across part of the answer (the location of the Caribbean Sea on a printed map) when doing a related task (Code 8). On a subsequent occasion (Day 4/30) he was shown another part of the answer (the location of "an island" where Puerto Ricans come from: Code 5). Twice (Day 4/31, 4/196) he heard mention of a boy who "comes from Puerto Rica" (Code 10).

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[5] Content code numbers are defined in Appendix D.

[6] Each quarter minute is numbered consecutively through each day

[7] L&R = Learned and remembered, L&F = Learned and forgotten, N-L = Not learned

8. *Learning and the Content of the Stream of Information (Step E)*

Step E involves determining if, or when, the pupil constructs an item-relevant schema. The procedure involved in this step is set out in Figure 5. This figure has been constructed as a model of the information processing and memory storage processes that actually take place in the pupil's mind. It is also, and primarily, a procedural model, intended to describe the sequence of analysis decisions that need to be carried out. These are:

1. Incoming information is evaluated for the presence of significant types of information (e.g. explicit item answers, partial item answers) and this information is transferred to a temporary store.
2. The temporary store is evaluated to see whether sufficient relevant information has been accumulated to form the core of an item-relevant schema.
3. Once an appropriate accumulation of information is present in the temporary store to form a schema it is transferred as a schema to memory
4. Once a schema has been transferred to memory, all further item-relevant information gets attached to it.
5. Information coming into the temporary store is deleted (forgotten) if there is nothing already there to attach itself to, or if no further significant item-relevant information arrives before forgetting occurs (i.e. a specified time period elapses).

The key to whether information gets used to form an item-relevant schema lies in the evaluation of the content of the temporary store. This evaluation takes into account both the type and content of the information the pupil is exposed to, and also the timing of that information. The rules that govern this evaluation are set out in Appendix D.

Application of these rules to the example (from Study Three) of Jon learning the location of Puerto Rica produces the following analysis. Please refer again to Appendix B.1 for the full details of the item file.

(1) Jon's first relevant experience involves him in looking at a map of North America and identifying, with a peer, where the Caribbean Sea is located. This partial (visual) information (Code 8) gets placed in the Temporary Store (Figure 5). According to Rule 2.3 it may disappear from this store unless further information is placed there on the same day.

(2) Jon is provided with an explicit item answer (Code 1) on the following day (Day 2/90, ".. Puerto Rica which is? .. an island in the Caribbean"). This gets placed in the Temporary Store (Rule 2.1) and will also disappear unless further information occurs on the same or a subsequent day.

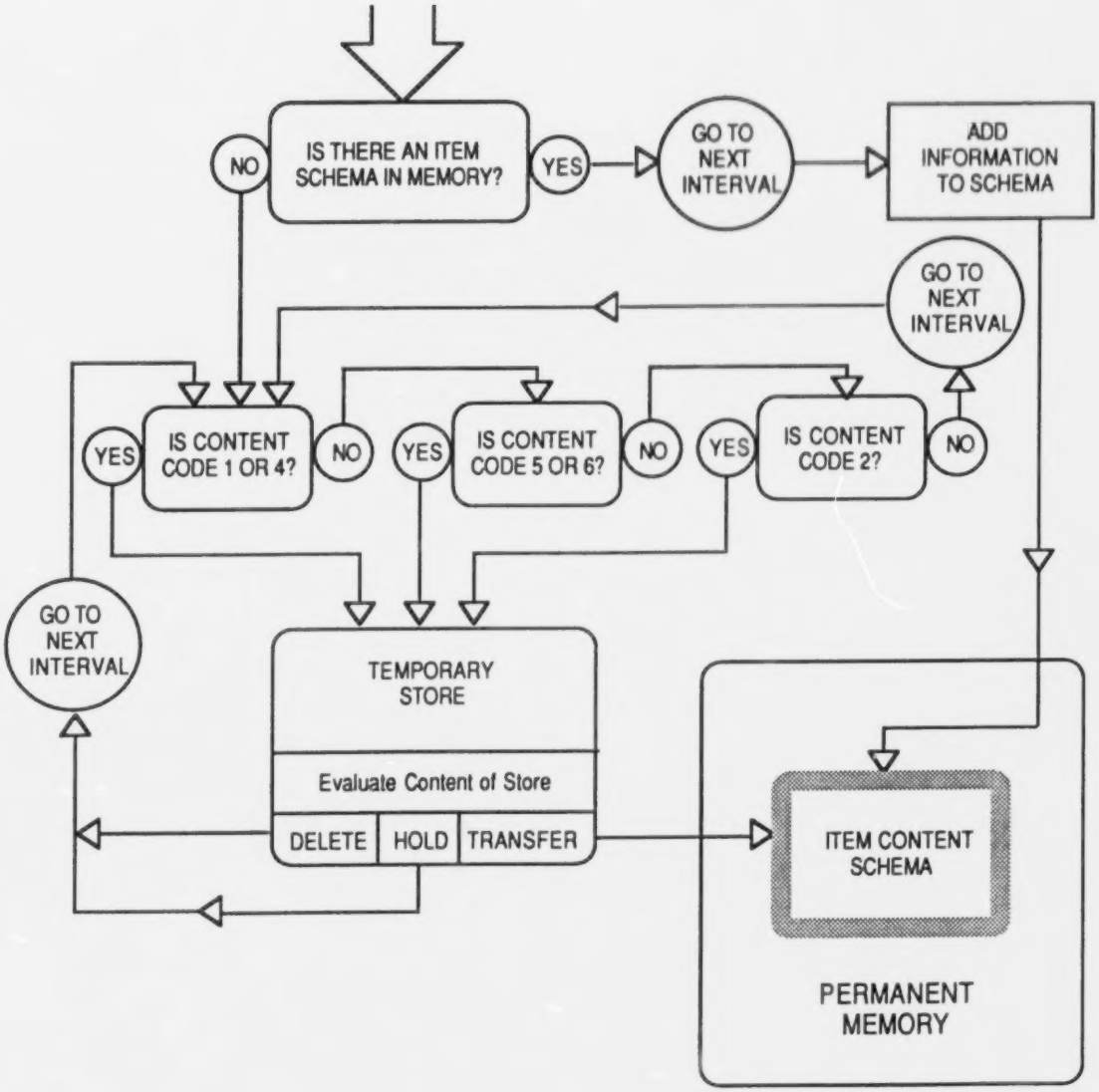

Figure 5. Model of pupil information processing: Transfer of information to memory

(3) At the same time, the OHP provides further partial information (it shows 'Puerto Ricans' connected by arrows to 'a Caribbean island', Code 5). This gets added to the temporary store and is retained there because an item answer (Code 1) has just come in (Rule 2.3.2).

(4) On the same OHP there is additional related information ('speak Spanish, own music, dress, food' Code 7) which also gets added to the Temporary Store (Rule 2.4) and is retained because there is already Code 1 information there (Rule 2.4.1).

(5) The next day (Day 3/81) Jon reads information which provides the item answer a second time (.. Puerto Rica is a Caribbean island associated with the United States ..'). The addition of this to the Temporary Store means that there is now sufficient information in the Temporary Store to form a schema which is transferred to memory (Rule 1.2)

(6) The following day (Day 4/22) Jon hears a discussion with the teacher in his group in which the teacher confirms the item answer ("Where is Puerto Rica? .. it was an island .. The Caribbean Sea"). Because a schema already exists in memory, this repetition of the answer gets added directly to the schema in memory (Rule 3.1).

(7) The same day (Day 4/30) Jon hears a discussion in which the teacher identifies the location of Puerto Rica on a sketch map on the blackboard, and also learns that the hero of a story he reads is a boy from Puerto Rica. These additional pieces of information, and all that is associated with them get attached directly to the schema that now exists in memory (Rule 3.1).

Applying the knowledge acquisition rules (Appendix D) leads to the prediction that Jon should have constructed a schema containing the information: 'Puerto Rica is a Caribbean island' by Day 3, Time 81. This schema should have attached to it the information that Puerto Ricans speak Spanish, have their own music and food, and live like the boy in the story about 'Riki'. Figure 6 contains a diagram of the content of this schema

8 Identifying Pupil Interaction with the Stream of Information (Step D)

The fourth step in the analysis of the pupil's knowledge construction process is to determine the extent to which the pupil is actively attending to, or interacting with, the available information. There are two types of data which can be used for this purpose. First are observational records of what the pupils were doing at the time when the information was available to them (e.g. when the teacher made a relevant statement). For example, during Jon's first exposure to the answer to Item #6, he was recorded as watching the teacher, looking at the overhead transparency projected on the screen and fiddling with his hands. During his second exposure, he was recorded as

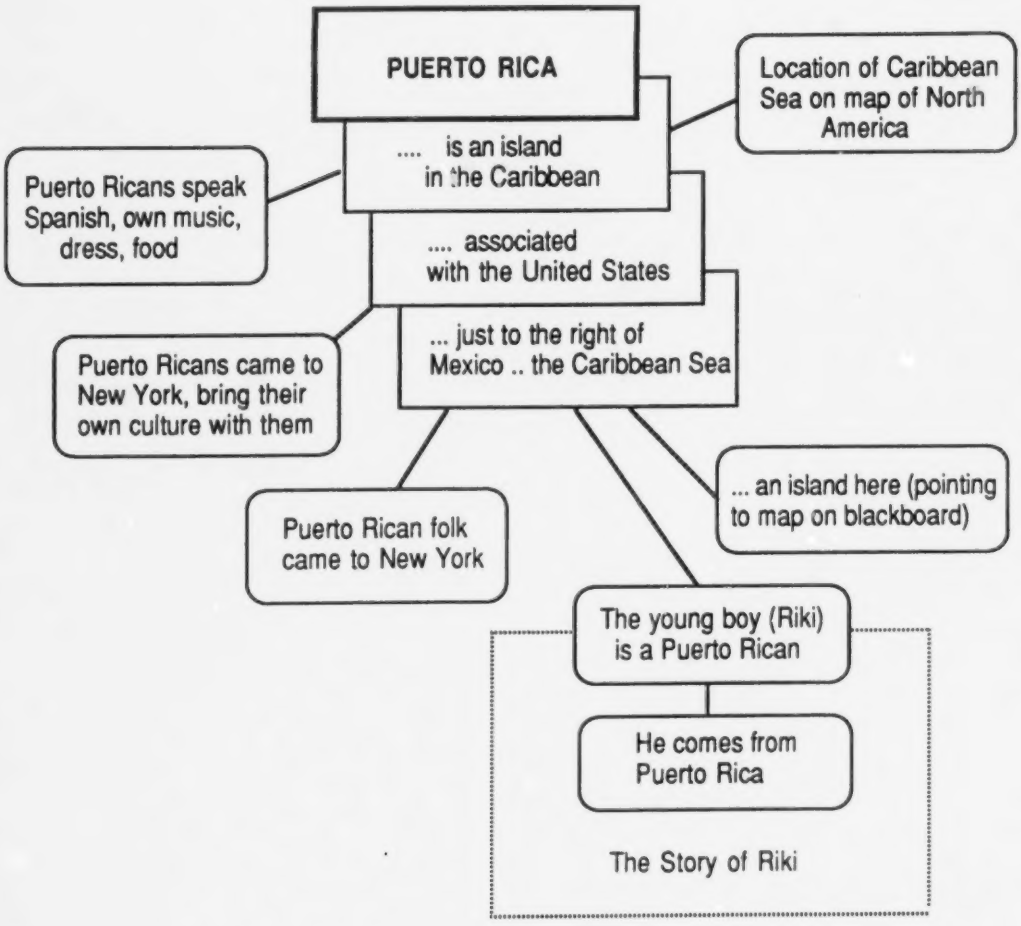
PUERTO RICA
Location of Caribbean Sea on map of North America
.... is an island in the Caribbean
Puerto Ricans speak Spanish, own music, dress, food
.... associated with the United States
... just to the right of Mexico .. the Caribbean Sea
Puerto Ricans came to New York, bring their own culture with them
... an island here (pointing to map on blackboard)
Puerto Rican folk came to New York
The young boy (Riki) is a Puerto Rican
He comes from Puerto Rica
The Story of Riki

Figure 6. The content of Jon's schema on the location of Puerto Rica.

reading and turning the pages of the worksheet which was the source of the information.

Second, there are the transcripts of the public and private statements made by the pupils and the teacher (recorded by both the whole-class and individual broadcast microphones) and the copies made of the material read, written, drawn, coloured, etc., by the pupils. For example, the comments by Jon and a peer during the time they were looking at an atlas map of North America (Item #6, Day 1, Time 169) were recorded from a microphone that Jon was wearing. They indicate what he was attending to and (possibly) thinking about at the time. (For details see appendix B.1)

In order to use the observations of pupil behaviours to determine how the pupils were interacting with available information, a functional coding of pupil behaviours has been developed which takes into account the relationship of the behaviours to the source of available information and to

the task requirements. These functional behaviour codes are listed in Appendix E. The following examples of behaviours classified by these categories have been drawn from the abbreviated item file for Study Three Item #6 reproduced in Appendix B.1

During Jon's exposure to information relevant to Item #6 (Appendix B.1, Day 1, Time 169) he was set the task of identifying the location of New York, Mexico, etc., on a map. His behaviours (talking to peer, looking at atlas, writing on his own map sheet) are all appropriate to the task. Because each of these indicates involvement with relevant information and actually getting or using the information, they are classified as *1.22 Task Appropriate, Active Cognitive Processing: Productive.*

On Day 2, Time 89, the context is one of public discussion, with relevant information displayed on the overhead screen. Jon's behaviours (watching teacher, watching screen) are appropriate, but there is no clear evidence of involvement with the content. Hence they are classified as *1.1 Task Appropriate, Informative Behaviours* Jon's other behaviour (fiddling with hands) would, in the absence of evidence that this has special significance for Jon, be classified as *3. Neutral behaviour* .

At the same time, Joe's behaviours (chin on hands, calling out "Caribbean, Caribbean") would be classified as *3. Neutral Behaviour* and *1.21 Task Appropriate, Active Cognitive Processing: Expressive.* Calling out "Caribbean" is classified as expressive because it indicates what Joe knows. Note that this utterance is also used in the process of validating predictions about the nature of Joe's cognitive processing (Step F below).

During this same time interval (Day 2, Time 89), the first two of Ann's behaviours (glancing round, swinging legs) would be classified as *3. Neutral Behaviour.* The third (talking to self "South America") would be classified as *1.21 Task Appropriate, Active Cognitive Processing: Expressive,* although it is not clear whether she is indicating puzzlement, a misconception, or misreading of 'Southern USA' on the screen.

During the next time segment (Day 2 Time 90) Ann is reported as talking and listening to peer ('Puerto Ricans'. 'Oh, I put something different again.'). This would also be classified as *1.21 Task Appropriate, Active Cognitive Processing: Expressive* because it indicates what Ann knows.

On Day 3, Time 90, Joe is recorded as reading the task sheet and talking with peer ('I've got it. Immigrants ... Oh, yes, I was so. ... Drugs. Narcotics are drugs, dumbo'). The reading of the task sheet would be classified as *1.22 Task Appropriate, Active Cognitive Processing: Productive,* but the talking with peer would be classified as *5.2 Alternative Behaviour: Active Cognitive Processing.* Here Joe is engaged with content which is not relevant to the item on the location of Puerto Rica.

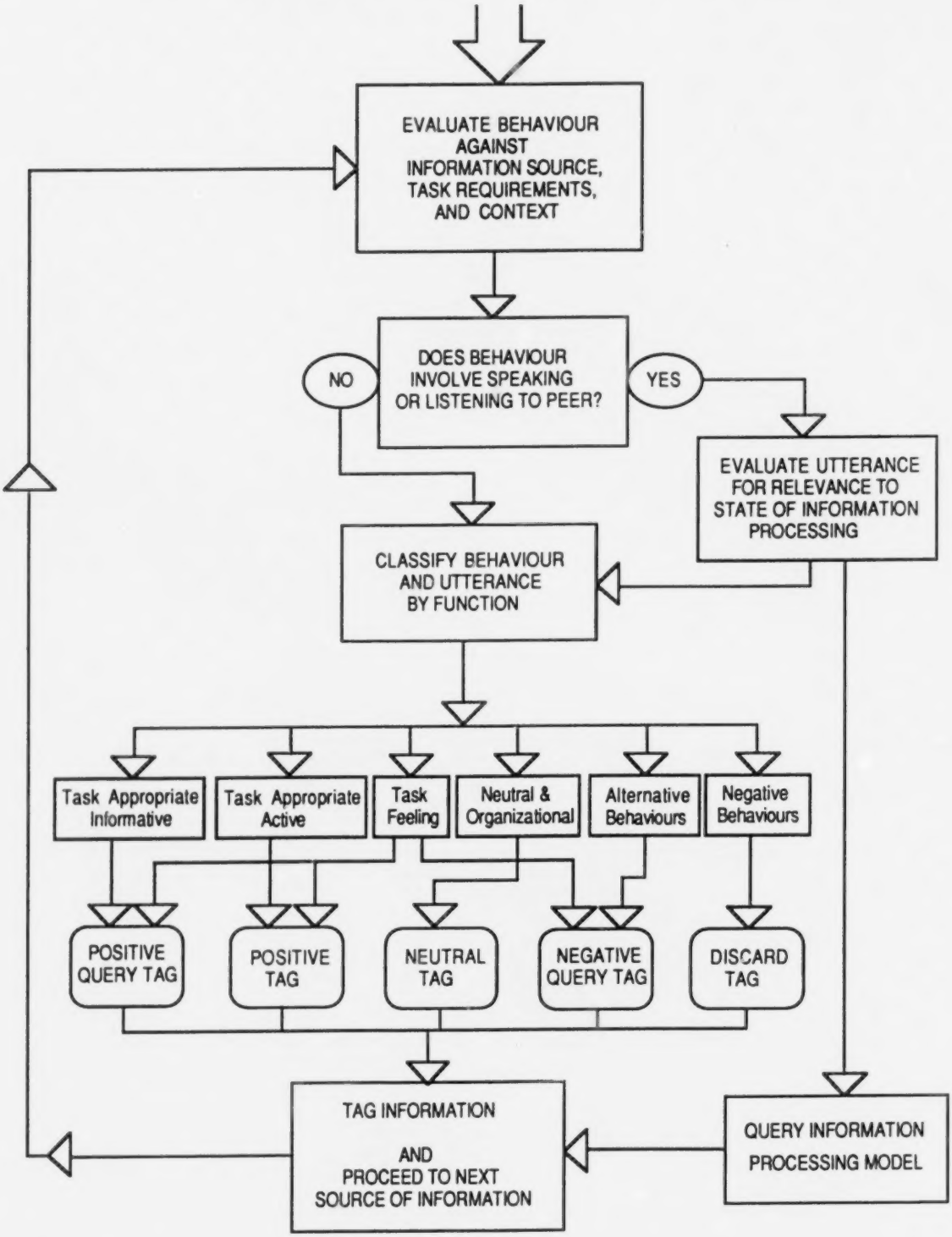

Figure 7. Model of procedure for tagging information content and monitoring the learning process

Step D is completed by relating the functional classification of each behaviour or utterance to the information that the pupil is potentially exposed to at the time. This is referred to as the process of 'tagging' each piece of information. A model of this process of 'tagging' is set out in Figure 7. The *positive* tag is used when the behaviours (or utterances) clearly indicate that the pupil is actively involved with the information. The *positive-query* tag is used when the evidence is ambiguous but probably positive. Where the pupil's behaviour indicates that attention is clearly focussed on irrelevant activities, the information available at the time is given the *discard* tag. The *negative-query* tag is used when the behaviour suggests, but does not clearly establish, that attention is focussed elsewhere.

As the labels suggest, the 'tags' indicate what is done with the information when it is used in the analysis process described in Figure 5. Information with a *positive* tag may be given additional weight. Information with a *discard* tag is treated as though it did not occur.

10. Example of Applying Steps C, D and E

The following is an example of applying the three steps described so far (Step C identifying the stream of information, Step D tagging, Step E predicting schema construction). The item was concerned with the current population of New York. As the item file (Appendix B.2) indicates, Jon learned the correct item answer from exposure to the answer on several different occasions over several days. Table 2 contains a summary of applying Steps C, D and E to the item file.

During the first occasion when Jon is exposed to the complete answer (Day 1/107) he is recorded as looking at the video-camera and telling another pupil next to him that 'The camera's on you'. This raises the possibility that Jon may not have been listening to the discussion at that point, hence the *negative-query* tag attached to it. In the next quarter minute, the teacher repeats the correct answer then turns to focus on the OHP map of New York. Jon is recorded as commenting on the map to a peer. However, it seems likely that he did hear the teacher before he started to talk. Hence the tag is *positive-query*. The question mark beside it indicates the doubt about this tag.

The next time Jon is exposed to an item answer is on Day 2/9. Jon is recorded as watching the teacher talking, so this interval is given a *positive-query* tag. In the next interval Jon is recorded as raising his hand while the teacher is describing the population of New York. Hand raising is taken to represent active involvement and given the *positive* tag.

On Day 3/74 Jon is recorded as reading the item answer in a worksheet. In this context, with the worksheet as the source, this behaviour is coded as 1.22 (active cognitive processing: productive), and is given the *positive* tag. However, on Day 5/31, Jon is reading a worksheet while the teacher is commenting about the population of New York. Jon is also recorded as

glancing at the teacher while the teacher is talking. Since the source of information is the teacher, the reading behaviour is not coded as 1.22. Nor is it coded as 5 (alternative behaviour) because Jon does look at the teacher, indicating that he did not continue reading through the time the teacher was talking. This leaves the possibility that Jon could well have heard the teacher's comment. Hence the *positive-query* tag.

Table 2. Formal analysis of Item File for Item #28 for Jon

DAY	TIME	CODE	SOURCES	BEHAVIOUR[8]	TAG
1	105	7	Tchr, pupil	1.21	Positive
	106	5	Tcher-pupil	1.22	Positive
	107	1	Tchr-pupil	5	Negative query
	108*	1	Tchr, Ohp-map	1.1	Positive query?
	125*	1	Tchr, Ohp-map	1.1	Neutral
2	8*	7	Tchr	1.1	Positive query
	9*	1	Tchr-pupil, Ohp	1.1	Positive query
	10*	1	Tchr, Ohp	1.21	Positive
	13	2	Ohp	1.1	Positive query
	14	1	Tchr, Ohp	1.1	Positive query
3	74	1	Worksheet	1.22	Positive
	95	10	Own work	1.22	Positive
5	21	7	Tchr, Worksheet	1.22	Positive
	31	1	Tchr, Worksheet	1.1	Positive query
	37	3	Worksheet	1.22	Positive
	55	7	Pupil, Worksheet	1.1	Positive query

* Note: The asterisks mark the period of time during which the item schema is constructed

Once the functional coding of the behaviour is completed and the tags attached to each interval, it is possible to complete the formal analysis of how Jon learned the content of the item. During Day 1, he was exposed to three occurrences of the item-answer (Code 1). The first occurrence has a negative-query tag which means that it probably did not go into the temporary store. There is no clear evidence that the second and third item answers went into the temporary store, either. It is probable that the second one did (positive-query? tag), but, as we indicated above, there is some doubt about Jon's attention to this information. Hence, by the end of Day 1 Jon may or may not have two occurrences of the item answer in his temporary store. On Day 2 however, there are three occurrences of the item-answer with positive or positive-query tags. This results in each of these occurrences being retained in the temporary store and this item-answer information forming a schema which is transferred to memory (Rule 1.3). The time over which this schema

[8] Behaviours in this column have been coded according to function in relation to source and context using the categories listed in Appendix F

is formed in the temporary store is marked in Table 2 with asterisks. The other information Jon experiences on Days 2, 3 and 5 becomes attached to the item-relevant schema when it has positive or positive-query tags attached to it (Rule 3.1).

11. Identifying the Role of Prior Knowledge and Beliefs (Step A)

So far, in order to simplify the analysis, the way prior knowledge influences the knowledge construction process has been ignored. Identifying the pupil's prior knowledge and beliefs, and determining how they might influence the knowledge construction process, should normally be the first step (Step A) in the analysis procedure.

It is assumed that pupils begin any unit with knowledge and beliefs that are relevant to the unit content and that this prior knowledge plays a role in the way the pupil interacts with the information that becomes available during the unit. The formation of item-relevant schema is controlled by previously existing knowledge. Where differences or contradictions exist between existing knowledge and incoming information, the pupil will resolve these by changing either the existing or the incoming knowledge.

In our data there were several sources of information on pupil prior knowledge and beliefs. The most significant of these were: the alternative answer chosen by the pupil on the pretest, the reasons or evidence the pupil gave for selecting specific test answers during the short- and long term post-test interviews (the content of these interviews was wide-ranging and often included information on related concepts and beliefs), the transcripts of pupil utterances, and the records of pupil writing and illustrating. For example, in the first study pupil drawings revealed key aspects of pupil beliefs about a concept taught in the unit (Alton-Lee, 1984). The following examples illustrate the way some of these sources of information have been used:

(a) Pretest Answers

The pretest answers provide clues about the knowledge pupils bring to bear on subsequent item-relevant experience. Interviews may supplement this evidence. On the pretest for Study Three Item #6 on the location of Puerto Rica (see Appendix B.1) Jon and Mia picked 'the capital of Peru', Ann picked 'an American port' and Joe selected 'I don't know'. Other evidence suggests that Jon and Mia selected 'the capital of Peru' because they had some knowledge of Spanish-American names and their association with Central and South America. Later interview evidence suggests that Ann's answer was based on the pronunciation of the word 'Puerto' which she associated with 'port'.

(b) Interview Data on Memory for Item Content.

The long term test interview on Study Three Item #6 with Ann and Joe indicate that they associated the sound of the word 'Puerto' with 'port' and thought of Puerto Rica as the name of a seaport. Ann seems to have maintained this misconception throughout the unit. Joe's interview indicates that he held both the correct answer and this misconception in mind. This suggests that the misconception came to replace the correct answer during the 12 months between the short term and long term post-tests.

(c) Interview Data on Related Concepts and Beliefs

The interviews with Joe about other items in the Study Three test (e.g. Item #25 People living in Central America speak? Spanish) indicated that he came to believe that not only was Puerto Rica a port but that it was attached to New York and inhabited by poor, Spanish speaking Puerto Ricans. The interviews with Ann about items dealing with immigration indicated that she thought that immigrants and commuters to a large city were the same people (' ... they go from the city back to where they live, but I can remember they travel quite a long way and it, and they, and that's why they're called immigrants.'). Thus, being an immigrant and living in a nearby port were not incompatible for Ann, supporting her belief that Puerto Rica was a port of New York and that Puerto Ricans were immigrants to New York.

By using pretest answers and interview responses in this way, it is possible to provide a description of the way a pupil's item-relevant knowledge and beliefs change from what they were at the beginning of the unit to what they become at the end of the unit, and what happened to them during the course of the unit. This description can be used to supplement and confirm or disconfirm the model of knowledge acquisition developed in Steps C and D. For example, it is sometimes possible to tell from pupil utterances whether a relevant schema has been constructed at the time the rules predict. It is also sometimes possible to tell, from evidence of the existence of a misconception alongside the correct answer, that the learning will be short term rather than long term.

12. *Identifying the Type of Item: (Step B)*

During the analysis of the data from Studies Three and Four it became apparent that there were variations in the nature of the learning process for different types of items. Five types of items were identified. These are:

1. *General Concept Items:* The item requires knowledge of a general or abstract concept. The answer to the item can be inferred from examples or instances, e.g.

Compared to New Zealand, New York is considered to have?

a high crime rate.
New York is made up of? people of many races.

2. *Visual Items:* The item requires visual as well as verbal knowledge, e.g.
Mark New York on the map of the world.
Manhattan is a similar shape to? a shoe.
Which of the following is the sign for a cold front (on a weather map)?

3. *Word Meaning Items:* The items asks for the meaning of a word, e.g.
What does 'ethnic' mean?
What does 'despondent' mean?
'Occasional' means?

4. *Specific Information Items:* The item asks for the recall of facts, names, events and descriptions e.g.
The population of New York is? 8 million
What area is known as the heart of New York? Manhattan
Broadway is? the longest street in New York

5. *Skill Items:* The item asks for the pupil to carry out a procedure, e.g.
Write down the temperature shown on this thermometer.

The following examples illustrate the differences in the analysis for these five types of items as well as differences in the way relevant knowledge is acquired for each type of item. The item files for each item referred to are reproduced in Appendix B. Constant reference to that Appendix will help to explain the way the data is being interpreted.

12.1. Items Involving a General Concept

Question #14 (Study Three) asks the pupils to compare the crime rate in New York with the crime rate in Christchurch. This item is classified as a general concept item because, in the context of the Study Three unit, there was considerable reference to instances and examples of crimes in New York.

The item file for this item for Mia is set out in Appendix B.4. In this example, Mia is exposed to a lot of examples of crime in New York, including types of violence (in the story of the Puerto Rican boy) outside her normal experience. Although there is no point at which Mia is informed that New York has a higher crime rate than Christchurch, her personal experience of Christchurch (which she refers to in the interview) provides her with the basis for judging the relative level of crime in New York. Mia's response to the task sheet exercise on Day 5 (5/42, 51, etc.) shows that by that day she has reached the conclusion that New York has a higher crime rate than Christchurch.

The formal analysis of this item file is set out in Table 3. There are three instances of content of Code 5 (Partial Item Information) on Day 1. The first instance of partial information is retained in the temporary store because further instances occur the same day (Appendix D. Rule 2.3.4). During Day 2,

an instance of Code 6 (Reasons and examples) gets added to the three pieces of partial information already in the temporary store (Rule 2.3.3). By the end of Day 2 sufficient instances of partial and example information have accumulated for the contents of the temporary store to be transferred to memory as an item schema (Rule 1.10). By the end of Day 2, Mia has been exposed to enough talk of violence, gangs and crime in New York within a short space of time for her to have formed the idea that there is a high level of crime in New York. Exposure to further examples on subsequent days results in these being added to this item schema in memory (Rule 3.1).

Table 3. Formal analysis of Item File for Item #14 for Mia

DAY	TIME	CODE	SOURCES	BEHAVIOUR	TAG
1	15	5	Tchr-pupil,Ohp	1.21	Positive
	22	10	Tchr,Ohp	1.1	Positive query
	23	10	Tchr,Ohp	1.1	Positive query
	27	5	Tchr-pupil,Ohp	1.21	Positive
	41	5	Ohp	3	Neutral
2	153	6	Tchr-pupil,Ohp	1.1	Positive query
	157	7	Pupil,Ohp	1.1	Positive query
	169	10	Tchr-pupil,Ohp	1.1	Positive query
3	161	6	Pupil,Bb	1.1	Positive query
	173	10	Pupil, Bb	3	Neutral
	174	10	Pupil, Bb	5	Negative query
	175	10	Tchr-pupil, Bb	1.1	Positive query
	176	10	Tchr-pupil, Bb	3	Neutral
	265	7	Bb	1.22	Positive
	286	8	Bb	1.1	Positive query
	300	6	Pupil	3	Neutral
4	216	6	Text	1.22	Positive
	227	6	Text	1.22	Positive
	228	6	Text	1.22	Positive
	231	6	Text	1.22	Positive
	235	7	Text	1.22	Positive
	284	7	Tchr, Text	1.1	Positive query
	285	6	Pupil,Tchr	1.21	Positive
5	42	7	Worksheet	1.22	Positive
5	51	7	Worksheet	1.22	Positive
5	88	7	Worksheet	5	Negative query
5	95	7	Worksheet	1.1	Positive query

Note that Rule 1.6 requires that the sequence of pieces of information coded as Code 5 needs to be checked to see if collectively they contain enough information to form the basis of a complete item answer. Information is coded as Code 5 (Partial Answer, Appendix C) if it contains part of the content of the test item answer. If a pupil is to learn from a sequence of partial

answers, the parts must add up to a complete item answer. Sequences of partial answers (Code 5) which do not cover all of the information a pupil would need to deduce and item answer do not fulfil the requirements of Rule 1.6.

12.2. Items Involving Visual Content

Items which involve visual content (such as locating New York on a map of North America, naming a picture of a barometer) require exposure to relevant visual information or experience. Appendix B.3 contains an abbreviated item file for an item from Study Four which involves visual content. In this item (#14) pupils were required to identify the symbol for the cold front on a weather map. The analysis of this item file for Rata's experience is set out in Table 4.

Table 4. Formal analysis of Item File for Item #14 for Rata (Study Four)

DAY	TIME	CODE	SOURCES	BEHAVIOUR	TAG
4	137	7	Map,teacher	1.21	Positive
	138	7,91	Map,teacher	1.21	Positive
	153	2	Map,teacher-pupil	1.21	Positive
	154	1,6	Map,teacher-pupil	1.22	Positive
	157	2,10	Map,teacher-pupil	1.1	Positive-query
	160-168	7,9	Map,teacher	1.1	Positive-query
	170	91	Map,teacher	1.1	Positive-query
	171-176	2,2	Map	1.1	Positive-query
	187	91	Map	1.1	Positive query
5	113	91	Map	4	Neutral
6	180	91	Map	1.1	Positive-query
	196	5	Map,teacher-pupil	1.1	Positive-query
	197	7	Map,teacher-pupil	1.1	Positive-query
7	223	2	Map,pupils	1.21	Positive
	224	2	Map, pupils	1.21	Positive
	225	5	Map,pupils	1.21	Positive

During the first two item-relevant intervals (4/137,138), the teacher is giving instructions for pupils to look at copies of the two newspaper weather maps he has given them. The maps have a legend printed underneath them which contains the answer to the test item (see Appendix B.3). During these and subsequent intervals Rata is recorded as looking at the maps but it is not clear whether she actually looks at the symbol for a cold front in the legend. Hence the content code is 91 (peripheral resource).

During the next two relevant intervals (4/153,154) a pupil identifies a cold front on the weather map and, in response to a question from the teacher, refers to the picture of a cold front in the legend below the map. The teacher then describes what a cold front looks like ('that thing with lines and triangles on it'), and a pupil adds a visual analogy ('like water'). There is one explicit item answer (Code 1) in this discussion (the teachers verbal description of the appearance of a cold front). There is also the reference to the symbol for the cold front on the map, and the pupil's visual analogy (Codes 2, 6). Rata is actively involved in this discussion, responding to the teacher's question about the legend under the map. During the next relevant interval (4/157) a pupil makes an explicit reference to the symbol for a cold front on a weather map (Code 2).

Rata has now experienced an instance of Code 1 information, two instances of Code 2 information, and an instance of Code 6 information. The rules for visual items (Appendix D) specify that explicit visual information (Code 2) is needed in combination with explicit verbal information (Code 1) for a visual-item schema to be constructed. Thus, under rule 1.1 (modified to include visual information), Rata should have constructed an item-relevant schema by time 4/157.

During subsequent days, Rata has several opportunities to see the symbol for a cold front when she is working with weather maps. On Day 7 (7/221-240) there is evidence during the discussion between Rata and her group that she knows what a cold front looks like and can refer to it in discussion. So the schema must have been constructed by that time.

12.3. Items Involving the Learning of Word Meanings

The evidence from Study Three indicates that pupils at the age of 11-12 years can learn word meanings from being told what they mean or from seeing the words in appropriate contexts. Mia described how she learned the meaning of the word 'despondent' from context.

> Int: Where did you learn that word?
> Mia: In the lesson
> Int: Can you remember that?
> Mia: Yes. People being despondent and feeling despondent in their tenement buildings and things.
> Int: So that must have come up in the story?
> Mia: I think it might have done.
> Int: Do you think you knew that word before the unit?
> Mia: No, I didn't
> Int: So you remember discussing it?
> Mia: No. We didn't discuss it. But it was in the story, I think. The boy was feeling despondent about the way he was living and things.
> Int: So you think you probably learned that just from the story, working it out for yourself from the story?

Mia: I think it probably told you something else and that made it clear to you.
Int: Do you often learn words from reading, like that?
Mia: Yeah. Quite often. But then if it hasn't got any of those other sort of clues around it, generally you have to look it up in the dictionary or ask someone what it is.

The data from the word meaning item files in Study Three indicated that it took at least two examples of the word in context to result in the child learning its meaning. An example of learning the meaning of the word 'tenement building' from context is given in Table 5. The full item file on which it is based is given in Appendix B.6. Initially the references were only to 'buildings' in New York (Times 1/16,17,23). Then the teacher referred to a 'poor tenement type building' The context was a story about the place where a boy lives (Time 1/297).

The next day Jon heard the teacher refer to "somebody (living) next door ... in a tenement building" (Time 2/236). In this teacher statement, the word 'tenement' occurred in a context that included reference to 'people' and to 'building'. Two days later there were further references to 'tenement' in the context of a description of the living conditions of a Puerto Rican boy in New York (Times 4/47,74). On the final day, Jon was asked to respond to a task question about whether there are 'people living in condemned tenement buildings' in New York and/or Christchurch. In each of these cases the word 'tenement' was associated with 'buildings' and 'people living'. The constant association of the word 'tenement' with references to 'people living' made it possible for Jon to learn the meaning of 'tenement' from these experiences. The rule covering this kind of learning in Appendix D is Rule 1.5 (Two or more different instances Code 5 (subcode 21).

Table 5. Formal analysis of Item File for Item #57 for Jon

DAY	TIME	CODE	SOURCES	BEHAVIOUR	TAG
1	16	10	Tchr-pupil,OHP	6	Discard
	17	10	Tchr, OHP	1.1	Positive query
	23	10	Tchr, OHP	1.1	Positive query
	297	5(21)	Tchr, worksheet	1.1	Positive query
2	236	5(21)	Tchr-pupil	1.21x	Positive query
3	20	10	Pupil	1.1	Positive query
	22	10	Tchr, Picture	1.1	Positive query
	32	10	Teacher	3	Neutral
4	47	5(21)	Worksheet	1.21	Positive
	74	5(21)	Tchr, worksheet	1.21	Positive
5	28	5(21)	Tchr, worksheet	1.21	Positive
	48	7	Worksheet	1.21	Positive

There were no cases of pupils learning the meanings of words from context only in Study Four, so we have no evidence whether the same process can occur with younger pupils.

12.4. Items Involving the Learning of a Skill or Procedure

There were six items in Study Four which involved the pupils in performing a procedure. All of these items in Study Four were related to the pupils' ability to read the temperature from a thermometer. Because there were no procedure items in Study Three and the items in Study Four involved only one type of procedure, there was inadequate data on which to base an analysis of the learning processes that might be involved in procedure items. Consequently, no rules have been developed for predicting this type of learning.

The limited data that we have obtained suggests that a standard model of skill learning (involving instruction/modeling, practice, and informative feedback) can be used to understand the learning process involved. The following were the steps that occurred when the pupils learned the thermometer reading procedure in Study Four.

1. Teacher provides instructions and critical information
2. Teacher asks pupils to practice the procedure
3. Pupils help each other to carry out the procedure
4. Teacher provides informative feedback and/or revised instructions
5. Pupils help each other with instructions
6. Pupils provide each other with feedback

13. The Use of Utterance and Interview Data to Validate and Correct Learning Processes (Step F)

Utterance data is used both to identify pupil interaction with information (Step D), and also to validate or correct the predicted learning process (Step F). The following are the ways in which the utterance data gets used:

1. Evidence of the nature of pupil involvement in class activity

    1.1 Pupil is distracted from teacher talk
    1.2 Pupil is involved in class activity
        1.21 Pupil relates content to personal experiences
        1.22 Pupil expresses agreement or disagreement privately (to self or peers)
        1.23 Pupil adds additional relevant information privately
        1.24 Content-relevant jokes, verbal associations, word play

2. Evidence of knowledge about item-relevant information

    2.1 Pupil indicates knowledge of an item answer
    2.2 Pupil indicates does not know an item answer
    2.3 Pupil gives evidence of being confused or uncertain about item answer

3. Evidence about relevant cognitive processes

    3.1 Pupil discovers own mistake or lack of knowledge
    3.2 Pupil thinks aloud
    3.3 Pupil articulates instructions to self.
    3.3 Pupil expresses excitement and high level of interest
    3.4 Pupil expresses difficulty or frustration with item relevant content
    3.4 Pupil expresses tiredness or boredom

4.Evidence of supplementary sources of information

    4.1 Pupil identifies out-of-class source of relevant information or experience

We have already identified two examples of using utterance data to confirm the schema construction process (cf. the example of Step D, Joe, Item#6, Day 2/89 p.20 above; and the example of visual item, Rata, Item #14 Day 7/221-240, p.29 above). The following are two further examples which illustrate how utterance and interview evidence is used in Step F of the analysis procedures.

Example 1. Confirming the Nature and Timing of the Learning Process

The first example (from Study Three) illustrates the way both utterance and interview data can be used to validate the nature and timing of the learning process. It happens also to be a further example of learning word meaning through reading the word in context.

Item #45 asked for the meaning of the word 'condemned'. Appendix B.5 contains the item file for Mia's experience of the information relevant to this item, and Table 6 contains the formal analysis of the item file.

Examination of the item file for item #45 (Appendix B.5) shows that eleven of the first thirteen intervals relevant to this item contained only references to 'apartment', 'apartment building' or 'buildings of New York' (all Code 9). Since there was no reference to the word 'condemned', there is nothing from which Mia could infer the meaning of 'condemned'.

The next interval (Day 4/220), however, is critical. Mia read the word 'condemned' in the story about "Riki". In the interview Mia identified this story as the place where she read the word. The word is not defined in this story, but it is used at the beginning of a paragraph which describes the direlect and unsafe conditions in the Riki's apartment building.

The day following this single exposure to the word, Mia was engaged in a task in which she had to decide whether there are people living in 'condemned buildings' in New York and/or Christchurch. While she was engaged in this task, Mia answered a peer's question about the meaning of 'condemned'. The answer she gave indicated that, at that specific time, she understood the meaning of the word. This means that Mia must have learned the meaning the word before that time, i.e. on day 4/220. This task and the parallel

Table 6. Formal analysis of Item File for Item #45 for Mia

DAY	TIME	CODE	SOURCES	BEHAVIOUR	TAG
1	16	9	Tchr-pupil,Ohp	1.1	Positive query
	17	9	Tchr,Ohp	3	Neutral
	23	9	Tchr,Ohp	1.1	Positive query
	287	9	Tchr	1.21	Positive
2	203	9	Tchr	3	Neutral
	204	9	Tchr,picture	1.1	Positive query
	255	9	Pupil	3	Neutral
	261	9	Pupil	1.1	Positive query
	269	9	Pupil	3	Neutral
3	20	6	Pupil, Tchr-pupil	1.22	Positive
	22	9	Tchr, picture	1.1	Positive query
	31	9	Tchr	6	Discard
	32	9	Tchr	5	Negative query
4	220	5	Worksheet	1.22	Positive
5	52	6	Pupils,worksheet	1.22	Positive
	53	6	Pupil,worksheet	1.22	Positive
	54	6	Pupils,worksheet	1.22	Positive
	55	6	Pupils,worksheet	1.22	Positive
	63	6	Worksheet	1.22	Positive

discussion with the peer served to consolidate her learning of the word meaning and cause it to be transferred to memory as a schema (Rule 1.4)

In this example, the utterance data (what Mia said to a peer) was used as evidence for when she learned the meaning of the word 'condemned'. The interview data confirmed that the learning took place through reading the story about 'Riki'.

Example 2. Identifying Supplementary Sources of Information

The interview data may also provide clues about other sources of information that the child has access to. For example, the child may indicate that television or talking with parents or siblings out of school has provided relevant information. The following is an excerpt from an interview with

Mia (Study Three) about a test-item is which she was asked to identify Broadway as the longest street in Manhattan.

> Mia: Um, I think its a big movie theatre, but after the test I asked Mum if I was right, because, I didn't know, like subway, its sort of Broadway, subway. I get them sort of confused. .... I know its um, I think its the longest street. It could be because Broadway sounds sort of like subway, cause its got the "way" with a different word in front .... etc.

When an interviewer asked Ann how she learned that the area in New York where the rich live is called Park Avenue, she replied:

> Ann: Park Avenue, I think. Cause that's where Kimberly and her brothers and all that live, and that's that programme [Diff'rent Strokes]. And they are meant to be quite rich. I think they live there.

In this latter case, the interview data provides the only evidence about how Ann might have learned the answer to an item about Park Avenue (see later section on exceptions to predicted learning outcomes.

14. Checking the Validity of the Information

So far we have made the assumption in this paper that all of the information that the pupils have been exposed to has been either related to the test item (in the ways described in the content codes) or unrelated to the test item. However, there are occasions when the information is ambiguous or clearly misleading in relation to the test item answer. Sometimes this is because the teacher says something that is clearly incorrect, or because a pupil says something incorrect and this is either ignored or apparently supported by the teacher. In our data, the occurrence of clearly misleading information is relatively infrequent, but account does need to be taken of it when analysing the nature of the information that the pupils are exposed to.

We have developed a set of six categories for coding information on the basis of its validity or correctness in relation to the content of an item. These six categories are as follows:

1. Valid statement(s)
2. Ambiguous or mixed statement(s)
3. Corrected statement(s)
4. Incorrect statement(s)
5. Analogy or synonym
6. Irrelevant (i.e. no more than key word or related to a procedure)

Definitions of each category are given in Appendix F. So far we have not incorporated this validity coding into the analysis procedure as a separate step. Information which is given validity code 4 (incorrect statement) is treated though it did not occur, in the same way as information which is

accompanied by negative behaviour and given a discard tag is also treated as though it did not occur. It may be possible, following more detailed analysis of the other types of validity to identify what effects they have on cognitive processing and to build in a refinement to the analysis procedures based on the validity coding. For example, information which is coded as ambiguous (code 2), corrected (code 3) or as an analogy or synonym (code 5) may be related to the development of misconceptions of the kinds discussed below (see discussion of exceptions to predictions, 2.1 and 2.2, pp 40-41).

15. The School Factor

As we indicated above, the analysis procedures described in this report were developed from analysis of the data in Study Three. This is why almost all the examples cited have been from Study Three. Since developing these procedures they have been applied to the data from Study Four. Because the pupils in Study Four were younger (9-10 years versus 11-12 years) and from a different cultural background (predominantly working class versus professional parental occupations, ethnically diverse versus predominantly white European) we expected there to be differences in the prediction rules (Appendix D) that related experience to learning. In fact, the only difference which emerged was in the amount of relevant experience that the pupils in Study Four needed before appropriate schema formation occurred.

The need for this additional relevant experience was accommodated by modifying Rules 1.1, 1.2, and 1.3 (Appendix D) to include one additional piece of information. Rules 1.1 and 1.3 require an additional instance of Code 1 or 4 information, Rule 1.2 requires an additional instance of Code 5 or 6 information. These changes do not alter the type of learning process or the type of information required in any way. They merely increase the amount of required information by the addition of a further instance of the same types of information that were required in the rules developed for Study Three.

It is, of course, not possible to determine why pupils in Study Four require more experience of relevant information in order to construct an appropriate schema in memory. There was a different teacher, a different curriculum area, and the pupils were younger and came from backgrounds less like the standard cultural context of the school. Analyses of the other dimensions of classroom experience may help to specify more precisely possible reasons for the difference.

16. Summary of Analysis Procedures

This paper has described the six steps which have been designed to determine, from the recorded data, if, when, and how a pupil acquires the knowledge needed to answer a test item. In summary these steps are:

A. Identifying the type of answer required by the item.

B. Identifying the item-relevant knowledge and beliefs that the pupil starts the unit with.

C. Identifying the content of the stream of item-relevant information which the pupil is exposed to, and classifying the validity of that content.

D. Identifying how each pupil interacts with the information by analyzing the behaviours occurring at the same time.

E. Determining if and when an item-relevant schema is formed by applying the knowledge acquisition rules.

F. Validating and correcting the cognitive processing predicted in Step E. from the relevant utterance and interview data.

17. Predicting Learning Outcomes

At the time of writing this paper, the analysis procedures described above have been applied to the data for the four pupils in Study Three and the four pupils in Study Four. The results of applying the analysis procedures to the item files for the four pupils in Study Three have been set out in Table 7.

The average number of items for which learning outcomes could be predicted using the rules set out in Appendix D was 83.2 percent across all items for all pupils. Prediction of items learned was more successful than the prediction of items that were not learned. The predictions were most successful for Jon and Mia, and least successful for Ann. In particular, it was the prediction of the outcomes for items which Ann did not learn that was least successful. Comparing the different types of items, it is clear that the prediction of learning for the visual items was the least successful. The number of items involved in this category is small, so failing to predict the outcome of one item (#2 locating New York on a map of North America) for three of the pupils made a substantial difference to the average prediction success in this category.

Table 7. Numbers of Item Learning Outcomes Predicted for Study Three

	Outcome Predicted					Outcome Not Predicted					
Type of Item	Jan	Joe	Ann	Mia	Total	Jan	Joe	Ann	Mia	Total	% Predicted
ITEMS LEARNED											
Specific Information	6	6	9	14	35		1	2	3	6	85
General Concept	2	3	2	2	9		1			1	90
Word Meaning	1	4	4	5	14		1			1	93
Visual	3	2	2	3	10			1	1	2	83
ITEMS NOT LEARNED											
Specific Information	1	6	8	6	21			3		3	88
General Concept	1	1	2	2	6			1		1	86
Word Meaning	2	2	3	4	11	1	1	1	1	4	73
Visual		1	1	1	3		2	1	1	4	43
Totals	16	25	31	37	109	1	6	9	6	22	83.2

Table 8 reports the results of applying the analysis procedures to the data for the four pupils in Study Four

The average prediction success for the items learned and not learned by the four pupils in Study Four is very similar to the prediction success for the pupils in Study Three. If the skill items (for which no prediction rules have been developed) are removed from the data for Study Four, then the prediction success is identical for the two studies (83%). This indicates that the analysis procedures developed on the basis of the data in Study Three have worked equally well with the data from Study Four. The one modification which was made is described in section 15 above (*15. The School Factor*). It involved requiring the pupils in Study Four to have had experience of slightly more relevant information before they could construct an appropriate schema.

In Study Four, the prediction of learning outcomes was most successful with Jan, and least successful with Rata and Tui. For Rata, most of the items for which the learning outcome was not predicted, dealt with content that occurred in a personal written project that Rata completed at the same time as the weather unit. Although the content of this additional project was included in the analysis, the prediction rules did not work so well with this unusual of out-of-class experience.

Table 8. Numbers of Item Learning Outcomes Predicted for Study Four

Type of Item	Outcome Predicted					Outcome Not Predicted					% Predicted
	Jan	Pam	Rata	Tui	Total	Jan	Pam	Rata	Tui	Total	
ITEMS LEARNED											
Specific Information	6	10	8	6	30	1	2	3		6	83
Word Meaning			1	1	2			2		2	50
Visual	3	2	2	7	14		1	1		2	88
Skill							1			1	0
ITEMS NOT LEARNED											
Specific Information	9	21	14	20	64	1	2	2	8	13	83
Word Meaning	1	1	1	3	6					0	100
Visual		1	1		2		1			1	67
Skill						1	1	2	2	6	0
Totals	19	35	27	37	118	3	8	10	10	31	79

For Tui, all the prediction failures occurred with items he failed to learn. They were all cases where the data indicated that he should have learned. As the discussion below of the exceptions indicates, there were special circumstances relating to Tui's involvement in class activities.

It is interesting to note that there is a tendency, in both studies, for the more successful pupils to learn more than the analysis procedures predicted and for the less successful pupils to learn less that the procedures predicted. As the discussion below of the unexplained exceptions suggests, there is need here for additional information relating to the personal and cultural differences between pupils.

18. Analysis of the Exceptions to Predicted Outcomes

As Tables 8 and 9 indicate, there were 23 instances of failure to predict learning outcomes for the items for all four pupils in Study Three, and 24 instances (excluding the skill items) of failure to predict in Study Four. Analysis of the item files for each of these instances suggested that there were five different reasons why the learning outcome was not predicted.

There were three reasons why an item was learned when the rules predicted that the item would not be learned. These were:

1.1 Item answer deduced from related information

1.2 Item answer learned from out-of-school experience
1.3 Passive visual materials available

There were two reasons why an item was not learned when the rules predicted that it would be learned. These were:

2.1 There was evidence of the pupil holding a misconception
2.2 The class experience contained contradictory or confused information

Finally, there was the special case of the failure of three of the four pupils in Study Three to learn the location of New York on a map of the world.

The nature of these reasons and the processes involved are as follows:

1.1 Deduction from related information.

The cases in this category are those in which it is clear that the pupil has derived the answer from information that was not classified as item-relevant. For example, Mia learned the answer to Item #25 (Most of the people who live in Central America speak? Spanish) without sufficient item-relevant information from which to learn the answer. Mia said in the post-test interview that she thought the question was about America or New York, not Central America. On three occasions during the unit, Mia was exposed to the information that Puerto Rica is in the Caribbean, that Puerto Ricans immigrated to New York, and that Puerto Ricans speak Spanish. Later she heard the teacher talk about 'language' as a problem that Puerto Ricans living in New York have. On the last day of the unit she worked on a worksheet which required her to decide whether 'people speaking Spanish' is true of New York or not. She wrote that it is true.

It is clear, from what Mia wrote on the worksheet on the last day, that she learned that there are people in New York who speak Spanish. Either by misunderstanding the question, or by generalizing from New York to Central America (via Puerto Rica), Mia concluded that Spanish is the language spoken in Central America.

1.2 Learned from out-of-school experience

There was one example in Study Three of an item being learned from identifiable out-of-school experience. Ann learned Item #83 (If you wanted to see where the rich people live in New York you would go to? Park Avenue) although there was only one mention of 'Park Avenue' during the whole unit. During the post-test interview, Ann said she gave 'Park Avenue' as the answer " ... because that's where Kimberly and her brothers and all that live, and that's that programme (*Diff'rent Strokes*)". It is also clear from the interview that Ann was watching the television programme *'Diff'rent*

Strokes' before or during the unit. She answered another post-test question about the content of *'Diff'rent Strokes'* correctly. On this evidence, it seems likely that the television programme provided Ann with the information she needed to answer the question.

1.3 Passive visual materials available

One of the difficulties of identifying children's experience in the classroom arises when relevant material is present in the classroom in a place where the child can look at it at any time. For example, in each of the studies there were coloured illustrations on the classroom walls and written or diagram material left on the blackboard for long periods of time. Where it is clear that a pupil is looking at the material, this is recorded and coded. But there is a high probability that there were many occasions during a school day when a pupil might look at the material unobserved.

This also occurs when a pupil is working on the materials relevant to a task. These materials may be available on the pupil's desk and although the observers may record the pupil attending to other sources or materials, it is likely that unobserved attention did occur.

For example, in Study Four, the pupils made constant use, when they were recording the weather outside their classroom, of a printed sheet containing the Beaufort Wind Scale. This sheet contained descriptions of the range of wind forces from 0 (calm) to 12 (hurricane). Almost all of the time they used this sheet they focussed on the descriptions of wind forces in the lower middle range (force 2 to force 5). There was, however, a question in the test (Item #88) which asked 'Which is the strongest wind?' This wind (force 12, hurricane) was described at the bottom of the sheet. There was no specific observation of any of the pupils actually reading this bottom part of the sheet. Jan learned the answer to this item although there was only a single recorded reference to a force 12 wind during the course of the unit. It seems probable that she attended, unobserved, to the bottom part of her sheet on some, if not all, of the many occasions on which she was observed to be using it.

2.1 Evidence of misconception

Exceptions were classified in this category when it was clear from interview evidence that the pupil had a misconception about the answer that was interfering with the process of constructing an item-relevant schema from the available information.

In Study Four, there is a question about what clouds are made of. The correct answer is 'little drops of water'. All four of the pupils select the incorrect alternative 'white gases' on the pretest. Three of the four continue to select this wrong alternative on the short term and long term post-tests. As Tui

indicated in his interview, the theory that clouds were made of white gases was commonly held by his peers

> Tui: Lots of people were talking about, ah, people were saying clouds were made of gases and that.
> Int: When you say lots of people were talking, which people?
> Tui: Oh, Tony, I think
> Int: Oh, I see. People in your group or round about where you were sitting were talking about it.
> Tui: No. Everyone in the school.

Even when pupils were aware that clouds could contain small droplets of water, the idea that they were actually made of small droplets of water seemed to them to be highly implausible.

> Rata: White gases
> Int: Why do you think that?
> Rata: It said in the book. ... It said they're made of little drops of water and when they get full, when they're coming through the cloud to fall out, they, um, other drops of water join on to it and it makes a bigger drop of water and it falls out of the cloud.
> Int: I see. ...
> Rata: Yes and its made of white gases
> Int: OK, so why did you put that one (white gases, in the test)
> Rata: Coz that's what clouds are mostly made of (laugh)

When Jan is asked in her long term interview what the teacher might have said about clouds, she attributed the 'white gas' theory to him

> Jan: They're made of white gases. Last year, Mr. B. told us about what the clouds were made of, and ....
> Int: ... Mr. B., think back, what did he say?
> Jan: He said that it's just white gases, that's in the sky. that's all I can mainly remember, coz I don't know what the white gases are made out of. I'm not sure.

It seems there was a widely held belief among the pupils that clouds are made of white gases. This misconception continued to dominate their thinking despite reading and classroom experience to the contrary. Jan finally attributed the misconception to the teacher himself.

2.2 Contradictory or confused information

On a few occasions pupils were exposed to sufficient information from which to learn the answer to an item, but within that information was content which was contradictory. For example, in Study Three, Item #59 required pupils to identify the meaning of the word 'conform'. There were two occasions when they came across the word in a story. On the first occasion the text read:

> "Riki, a Puerto Rican ... now a teenager had always had a record of failure at school. Not only failure, the reports stated, with his grades at school, but a failure to conform, to co-operate, and to get along with his peers."

Later in the story, there is reference to Riki getting into a gang.

> "But growing up in the Bronx was easy -- if you didn't want to be a conformist. It was easy to get in with a gang of young hoodlums of your own kind ...

After the pupils read this story, the teacher discussed the meaning of the word 'conform'.

> T: ... what is it when everybody is doing the same thing ... if all your friends are doing a thing, there's something that makes you sometimes want to do it ...?
> Pupil: Peer pressure
> T: Another word ... the word begins with 'con-' ... Means to do the same thing as everybody else. Its in the story. ... Conform. If you can conform. Keep the same as everybody else. I don't think Riki wants to be too different ...

The first reference to 'conform' in the story suggests that Riki fails to 'conform'. The second reference also makes the point that the easy option of joining a gang is the opposite of being 'conformist'. Then the teacher says that Riki's desire not to be different from his peers is his desire to 'conform'. Thus the pupils were given the information that Riki both 'conforms' and doesn't 'conform', and that being a conformist is the opposite of joining your peers in a gang and the same thing as doing what your peers do.

None of the pupils learned the meaning of the word 'conform' except Joe, although Rule 1.4 (in Appendix D) predicts that they all should have learned it from the reading of the story and the teacher's discussion.

The special case of the map confusion in Study Three

All three pupils who did not know where New York was located on a map of the world before the unit, did not know it after the unit. During the unit a significant amount of time was spent on the location of New York on a map of the North American continent. The pupils were shown the location on a map on the blackboard, its location was described as the north-east corner of the United States, and they filled in New York on their own map of the North American continent. Two of the three pupils discused the location of New York with their peers while they were putting it on their map.

On the post-test, two of the pupils located New York on Hudson Bay, apparently confusing the Hudson River with Hudson Bay. The third pupil located New York on Greenland, apparently confusing the shape of the North American continent with the shape of Greenland on the map of the world in the test. According to both Rules 1.1 and 1.2 (Appendix D), these three pupils should have learned the location of New York. For two of the three pupils, there is utterance evidence and evidence on their map work that they knew the location of New York on the North American continent during the unit.

It is unusual that three pupils should fail to learn the same item. There were no other items in the post-test for Study Three which involved the use of a map, so there is no way of knowing whether there is something specific to learning map locations or whether it is just another example of misconceptions (confusing Hudson River with Hudson Bay, and confusing the shape of Greenland with the shape of North America).

Items where no explanation was evident

There were twenty items for which no explanation was evident for the failure to predict the learning outcome. Eight were items for which the answers were learned but there was almost no recorded relevant experience during the unit. Presumably relevant experiences occurred outside the unit, or outside the experiences recorded in our data.

In Study Three there were two items which dealt with historical facts (New York was bought from? the Indians; The English took New York from? the Dutch). Extensive information relevant to these items occurred during the unit and they were learned by three of the four pupils. However, Ann learned neither of them. It may be that Ann's understanding of the past or of historical sequence was less adequate than the others.

In Study four there were seven items for Tui and two items for Pam where extensive relevant information occurred during the unit, but the items were not learned. Informal examination of the data relevant to these items suggests that the explanation lies in other dimensions of the data. For example, Tui often engaged in behaviours which seemed designed to distance himself from involvement in classroom activities. On other occasions he focussed his attention on aspects of tasks which were peripheral to the central purpose of the tasks. There were clearly race and cultural issues that were very significant for him. Interviews with Pam gave the impression that she was often more interested in telling a plausible story than trying to get the answers to items right. This seemed to relate to her home experience where she formed part of a constantly shifting adult world.

These personal and cultural characteristics of pupils, which form part of the 'Personal development and interpersonal interaction' and 'Cultural' dimensions of our data need to be investigated more systematically before conclusions can be reached about the reasons for these exceptions to the prediction rules.

Frequency of reasons for explanations

Table 9 sets out the number of exceptions that were explained by each of the types of reasons described above. Overall these reasons provide explanations for 73% of the exceptions. The most commonly occurring reasons are a pupil's ability to deduce the item answer from indirectly relevant information, and the existence of a major misconception.

Table 9 Frequency of Reasons for Exceptions to Learning Outcome Predictions

Reason for Exception	JON	JOE	ANN	MIA	JAN	PAM	RATA	TUI	TOTAL
Deduction from related information		1	1	4					6
Out-of-School experience			1				2		3
Passive visual source					1	2	1		4
Misconception			1	1		1	2	1	6
Contradictory information	1		2	1					4
Map Confusion		1	1	1					3
No Explanation		3	3		1	3	3	7	20

At the time of writing this paper, the analysis procedures we have been describing represent what appears to us to be a coherent and plausible model of the learning processes involved in the data from Study Three and Study Four. Analysis of the exceptions to the rules based on this model indicated that there were identifiable reasons why the outcomes for many of these items were not predicted. It would have been possible for us to incorporate these reasons into the model as a further set of the general rules in Appendix D. However, this could lead to the model reflecting too closely the specific circumstances of the pupils' experience in Studies Three and Four. We decided, in the meantime, to leave the model as it stood and to report the analysis of the exceptions separately. Once the data from Study Two has also been analyzed, the consistently recurring reasons for exceptions to the rules will be incorporated into the general model of the processes that explain pupil learning.

19. The Nature of Pupil Learning and Classroom Experience

It is important to note that the analysis procedures described in this paper are both a set of steps for predicting learning and a descriptive model of how the learning process takes place. It would be possible, without much difficulty, to convert most of the steps in the analysis procedure into a computer programme[9]. Moving away from traditional quantitative analysis was not intended to be a move away from structured logical procedures so much as a move away from the limitations of using numerical frequencies and linear correlations as the sole basis for understanding and interpreting the data.

However, the steps involved in the analysis are not just any set of predictive data manipulations. They are based directly on a model of information processing which is intended to reflect the reality of the learning process in pupils. If a model is to provide a useful understanding of classroom learning then it must reflect what is actually happening to pupils and also be informed by the substantial body of research in cognitive science that deals with the acquisition of knowledge and skill and with memory processes (cf. Howard,1987; Stillings,et alia,1987).

The following is a summary of our understanding of the cognitive processes that determine how pupils learn in classrooms. It is an explanatory theory which will evolve and become more specific as we process more of the data in our studies.

19.1 How Does Information-Processing Occur?

It is important to note, when describing information processing that words (or pictures, texts, etc) do not convey information as though information were some kind of package that was handed from the speaker (writer) to listener (reader). It is more accurate to say that words (or pictures) stimulate the construction of information in the mind of the listener (or viewer). The listener must actively participate in the process, using the experience or knowledge available in memory, to construct the meaning intended by the speaker. In everyday language we say that the information comes from the source, and in describing the model in this analysis, we have used everyday language to refer to a stream of information to which the pupil is exposed. It would be more precise to say that the child is exposed to a sequence of stimuli (spoken and printed words, diagrams, pictures, etc.) which may stimulate the meaning or information construction process in the child's mind. Unfortunately, everyday language does not have words which describe the actual process simply.

Underlying the ambiguity in describing information-processing lies another important point. Because meaning and information is something which a

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[9] It is steps A, B, C and E of the analysis procedure which could be automated once the original data had been coded using the content and behaviour categories listed in Appendices D, F and G.

listener constructs, the kind of meaning or information which is constructed depends on the experience or knowledge the listener has available to use in the construction process. For example, what may appear to an adult to be an explicit answer to a test item, may not be an explicit item answer to a pupil who does not have the background experience that would lead her/him to understand (or reconstruct) the answer in the same way as the adult.

For example, during the course of the unit on New York. the children read that the island of Manhattan is 'shaped like a shoe'. Understanding this phrase required each child to draw on her/his experience of shoes and experience of 'Manhattan' and form an appropriate association between them. What shape does a shoe have? One child might have thought of a shoe seen from the top. Another child might have imagined a shoe seen from the side. If they had been asked to draw the shape of Manhattan these two children might have produced significantly different shapes. Both children 'understood' the phrase, but both were dependent on their own experience in constructing the meaning.

19.2. How Does Schema Construction Take Place?

There is a different kind of ambiguity about the meaning of the term 'schema'. Recent writing in cognitive psychology defines a schema as a structured cluster of information relevant to a specific topic, concept, or event, which is stored in memory (cf Howard, 1987). Schemas influence perception, guide the interpretation or understanding of incoming information, act as storage locations in memory, and guide memory search processes. While the idea of a schema has proved very useful for making sense of a large number of cognitive and language processes (cf. Furman & Walden, 1990), there is a temptation to think that the nature of a schema is well understood and that schemas are real entities that exist as objects in the mind. In fact there is good research evidence to suggest that a schema is not a thing or entity but a structural process.

The easiest way to describe this 'structural process' is to provide an illustration. Consider the schema that you might have for 'toothpaste'. That schema will include all that you know and have experienced about toothpaste (its colour, texture, purpose, where it is found, etc.). Now consider the schema you might have about 'toothbrush'. That schema will contain all that you know and have experienced in relation to toothbrushes (their appearance, composition, purpose, where they are found, different types, etc.). The problem is that a good deal of the content of the 'toothpaste' schema is identical with the 'toothbrush' schema. People's schema for these two objects show considerable overlap with each other. If every aspect of a person's knowledge was stored as a separate entity (schema) in memory, there would be a vaste amount of duplication in memory. A more sensible interpretation is that a schema is not a distinct thing in the mind, but is that collection of information, experience, etc, that you bring to mind when thinking about or experiencing something related to the schema. In other words, a schema is a

specific perspective or window on the contents of memory that serves to structure perception and experience but is not, itself, an object or structure in memory.

What then does it mean to say that a child 'constructs an item-relevant schema'? The simplest way to describe it is to say that the child organizes, or reorganizes relevant memory content in an item-relevant manner. Before an item-relevant schema exists, the appropriate experience may be stored in memory but no connections have been made between the elements of the experience and the item (or a key concept contained in the item). To use the example referred to above, when a schema is formed for the item on the shape of the island of Manhattan, the child must make connections between experiences of shoes and the unit-generated experiences relating to Manhattan. The experiences are already there in the child's mind. What is new is the creation of explicit associations between them. In this sense, constructing a schema is a process of forming links or making connections between relevant, already-known information.

19.3 The learning process implied by the model

Based on these definitions of information processing and schema formation, the learning process implied in the analysis procedures can be described as follows.

In order for a pupil to answer a test item correctly, the pupil must have available, in memory, a schema which brings together the information needed to identify or construct the answer. This schema will be constructed by a pupil if the pupil is exposed to a series of relevant experiences within a limited period of time, and the pupil already has available in memory the background knowledge needed to interpret and use the experiences appropriately. The nature of these experiences varies with the kind of test item (i.e. type of knowledge or skill). For example, test items requiring knowledge of visual information require the pupil to experience a combination of both verbal descriptions and visual information. Test items requiring knowledge of specific information require the pupil to experience both specific item answers and additional partial or background information such as reasons or examples.

Critical to the process of schema construction is the timing of the pupil's experiences. Gaps of a day or more between relevant experiences seem to result in a breakdown of the schema construction process. Since information relevant to one item is normally experienced interspersed with information relevant to other items, the pupil's mind must be engaged in processes (of identifying and allocating schema-related experiences) of the kind described by Bransford and Franks in their studies of 'semantic integration' (Bransford & Franks, 1971).

Underlying the schema construction process it seems that pupils have a desire to make sense of their experience. This process of 'making sense' consists of making sure that their beliefs are logically consistent with each other and with the available evidence as they experience and interpret it. For example, Jan (in Study Four) explains that rainbows are caused by sun on the rain 'because its always sunny after it rains and that, and there's hardly any wind after it rains.' This is Jan's interpretation of her experience of rainbows. Because of its idiosyncratic nature it is not something she could have learned from others. The interviews make it clear that some pupils have developed very elaborate idiosyncratic theories to accommodate experience and information that, to adults, would seem completely incompatible.

However, there were variations in the extent to which different pupils felt the need to make sense of the information they were exposed to in the classroom. Some accepted that what they were told was what they had to learn in school regardless of how absurd or contradictory it might seem. Some transferred this attitude to their own mental processes. For example, Tui (Study Four) appeared to accept that answers were either in your head or they were not. He explained his answer to one question by saying that 'something just goes through my head'. For another question, when he was asked why he didn't try to give an answer he said it was 'because nothing was going through my head'. On the other hand Pam (also in Study Four) felt compelled to provide reasons for her answers even when she was completely out of her depth. She explained that warm air rises because

> 'Well, it can't go .. if the air stays in one place, well then, the ... if the warm air stays in one place, then it would have to clear before dark because, ah, there could be some clouds pushing all the warm air away, so that the other side of town could have all the warm air .. while we have rain or something.' (laughs)

Modifying a pupil's desire to make sense of experience are the differences in pupils cultural backgrounds and their involvement in the culture of the school. The school itself may give contradictory messages about whether pupils should accept what they are told without question or should try to actively integrate their class experience into their personal beliefs.

19.4 Test Answering Processes

Data obtained in the interviews indicates that pupils' performance on the outcome tests was not simply a passive reflection of the knowledge and skills which they had acquired in class. Regardless of the nature of the questions which were asked in the test, pupils were actively involved in the selection and construction of answers. The relevant schema do not simply contain the test-item answers. Rather, they contain the knowledge that pupils can use in order to answer the questions. A preliminary report on the variety of test answering strategies which pupils use, and the beliefs they have about their own learning and memory processes has been presented elsewhere (Nuthall & Alton Lee, 1988).

19.5 The Social Construction of Learning Processes

In addition to the acquisition of knowledge, beliefs, and skills, there are clearly other kinds of cognitive learning taking place in the classroom. In Step F of the analysis procedures a description was given of how we used pupil utterances as indicators of the underlying learning process. There is, however, good evidence from other research (cf. Middleton & Edwards, 1990) that cognitive processes are, to some extent, socially constructed. If this is true then the utterance data needs to be interpreted not only as a sign of underlying cognitive processes but also as part of the process by which pupils learn to learn and remember. As Middleton and Edwards suggest, it may be in the interaction between pupils that their conception of memory is developed.

> The awareness of having and using a 'memory' and the awareness of its properties may well arise as a matter of difficulty — as a matter of not being able to remember something, of being suddenly reminded, of having something on the tip of your tongue, of trying to remember and of trying to square an offered version of events with what another speaker says. (p.28)

Pupils do have beliefs about how their minds work, how they acquire knowledge and how to tell what is the 'right' answer. These matters get discussed or argued about in class. We have not yet searched our data for evidence of how this 'social construction' might occur.

20. Where do we go from here to find implications for teachers?

The analysis procedures described in this paper are a way of understanding and predicting pupil learning from the kind of detailed data we have obtained from observing and recording pupils' classroom experiences. It is based on an analysis of the stream of information to which the pupils are exposed, either passively or actively. What this analysis does not do is look at how the pupils came to be exposed to the information, or how they came to engage in relevant activities. Understanding how activities in the classroom turn out the way they do takes us into the task-accomplishment dimension of the classroom. It will be the purpose of the analysis of this dimension to look at the relationships between how teachers set up and organize tasks and how pupils respond to those tasks.

For example, the analysis described in this report explains and predicts the consequences of a pupil obtaining information by reading a task sheet, or by looking up the location of a city in an atlas at a particular time. What this analysis does not do is explain why the pupil, at the particular time, read the task sheet or looked up the atlas. The analysis of the task-accomplishment dimension of the classroom will focus on how the teacher's structuring of a task leads to a pupil carrying out the relevant activities at an appropriate time.

This does not mean, however, that the understanding of the learning process described in this report has no practical relevance for teachers. It has the same practical significance that understanding the underlying process has for any functional activity. Without understanding performance will be automatic or rule-bound and liable to collapse when circumstances vary from the normal. What understanding provides is flexibility and sensitivity to variations in circumstances. In the case of the teacher's performance in the classroom, understanding the learning process also provides a basis on which to plan classroom tasks. It provides the teacher with an idea of the kinds of experiences that pupils need in order to acquire the knowledge and skills the teacher wants.

21. A Final Note on the Methodology of the New Data Analysis Procedures

It was always our intention in this project to make considerable use of the qualitative data in the interpretation of the quantitative results and in the development of explanatory theory. Our original methodological view was that the qualitative analyses should be interactive with the quantitative analyses. The identification of underlying processes should emerge early in the analysis and come to determine the nature of the analysis itself.

One way of describing the new analysis procedures is to say that they take the creation of a theoretical explanation of the learning process as a more immediate and critical task than traditional analysis procedures. For example, the observation-correlation-experiment-theory loop, discussed and quoted by Rosenshine and Gage (Cf. Rosenshine,1986), implies that theory is something which comes at the end of a sequence of observational, correlational and experimental studies. Once the range of established facts is extensive, theory can be developed by interpreting and explaining them. Statistical analysis is used to establish what is known and to provide the link between the original data and the development of theory. In contrast, the procedure we have developed brings an initial theory or model in at the beginning of the data analysis procedures, and then brings the data into more direct contact with this initial theory. The rules for predicting if and when an item-relevant schema will be constructed (Appendix D) are the connection between the data and the explanatory theory.

The theory that is referred to here is, however, not the grand theory that might be developed from an extensive body of statistically verified facts. It is the very limited and specific theory that is needed to predict whether one pupil will, or will not, learn the answer to a single test item. If grand theory is to be developed, it must come from the progressive expansion of explanations of specific item learning by individual pupils in specific contexts to include more and more items for more and more pupils in more and more contexts.

This implies, as we have argued elsewhere (Nuthall & Alton-Lee, 1990), that what should generalize across studies is not findings but theories. What

accumulates, as more and more research is carried out, is not more and more findings requiring a technique like meta-analysis to produce general conclusions, but more comprehensive, extensively applicable and widely validated theories.

References

Alton-Lee, A.G. *Understanding learning and teaching: An investigation of pupil experience of content in relation to immediate and long term learning*. Unpublished doctoral dissertation, University of Canterbury, Christchurch, 1984.

Alton-Lee, A.G. & Nuthall, G.A. Pupil experiences and pupil learning in the elementary classroom: an illustration of a generative methodology. *Teaching and Teacher Education*, 1990, 6: 27-45.

Alton-Lee, A.G., Nuthall, G.A. & Densem, P.A. Imperatives of classroom research: understanding what children learn about gender and race. In J.Morss & T.Linzey. (eds) *Growing up: Lifespan development and the politics of human learning*. Auckland, N.Z.: Longmans Paul, 1991.

Alton-Lee, A.G., Nuthall, G.A. & Patrick, J.M. Take your brown hand off my book: Racism in the classroom. *SET Research Information for Teachers*, 1987, No.1, 8. Wellington, N.Z.: New Zealand Council for Educational Research.

Bransford, J. & Franks, J. The abstraction of linguistic ideas. *Cognitive Psychology*, 1971, 2: 331-350.

Cole, A.L.. Personal signals in spontaneous teaching practice. *Qualitative Studies in Education*, 1988, 2: 25-39.

Furman, L.N. & Walden, T.A. Effect of script knowledge on preschool children's communicative interactions. *Developmental Psychology*, 1990, 26(2): 227-233.

Gage, N.L. The paradigm wars and their aftermath. *Educational Researcher*, 1989, 18 (7): 4-10.

Howard, R.W. *Concepts and schemata*. London: Cassell, 1987.

Jackson, P.W. *Life in Classrooms*. New York: Holt Rinehart &Winston, 1968.

Stodolsky, S.S. Teacher evaluation: The limits of looking. *Educational Researcher*, 1984, 13: 11-18.

Middleton, D. & Edwards, D. Conversational remembering: a social psychological approach. In Middleton, D., & Edwards, D. (eds) *Collective Remembering*. London: Sage Publications, 1990.

Nuthall, G.A. & Alton-Lee, A.G. *Children's test-answering processes and classroom learning*. Paper presented at the annual Conference of the Australian Association for Research in Education. Melbourne 1986.

Nuthall, G.A. & Alton-Lee, A.G. Research on teaching and learning: Thirty years of change. *The Elementary School Journal*, 1990, 90: 547-570.

Nuthall, G.A. & Alton-Lee, A.G. *Knowledge acquisition in the Classroom*. Technical Report Number Four. Learning and Teaching Project, Education Department, University of Canterbury, February 1991.

Rosenshine, B. & Stevens, R. Teaching functions. In M.C.Wittrock (Ed), *Handbook of research on teaching* (3rd ed., pp.376-391).New York: Macmillan. 1986.

Stillings, N.A., Feinstein, M., Garfield, J., Rissland, E., Rosenbaum, D., Weisler, S., & Baker-Ward, L. *Cognitive Science: An Introduction*. Cambridge,Massachusetts: The MIT Press. 1987.

Understanding Learning and Teaching Project: Study Three. First Report Focussed on Quantitative Data. University of Canterbury, Education Department, August 1990.

APPENDIX A.1 THE DESIGN OF THE FOUR STUDIES IN THE UNDERSTANDING LEARNING AND TEACHING PROJECT

The basic data gathering design used for each of the four studies was as follows:

1. *Setting Up*: A self-contained curriculum unit in science or social studies was selected in discussion with the teacher from the teacher's normal programme. The units selected were all integrated units involving a range of topics and skills. Content of the unit was identified from discussion with the teacher and initial interviews were held with pupils on their knowledge of unit content and attitudes. A 100 item test of unit content was developed to cover as much as possible of all pupil experiences planned by the teacher in the unit.

2. *Familiarisation and Training*: Permission for research procedures was sought from parents. Observers were trained and spent informal time in class. Pupils were familiarized with observers and recording equipment.

3. *Selection of Case Study Pupils*: Three or four pupils were selected by the researchers to represent differences in gender, race and ability within each class. The identity of these pupils was not revealed to the teacher until the debriefing after each study.

4. *Pretesting*: First administration of outcome test of unit content and of pupil questionnaires was carried out.

5. *Observation and Recording*: Continuous observations were made throughout the unit of case study pupils using one observer per child (rotated to avoid bias). Observers recorded all pupil behaviours, resources used and work done by pupils in quarter-minute intervals. Continuous audiorecordings were made of public talk using class microphones, and audiorecording of private pupil talk using individual wireless microphones. Videorecording (scanning teacher and pupils) were also made. Copies were made of pupil work, resources used, writing on blackboard, etc.

6. *Short term Post-test and Interviews*: Second administration of the outcome test of unit content, a sociogram and a questionnaire was carried out soon after the unit ended. Pupils were interviewed on content learned, on understanding of content and memory for class activities and own learning experiences.

7. *Long term Post-test and Interviews, 12 months later*: Third administration of outcome test of unit content was carried out twelve months after the unit finished. Pupils were interviewed on content learned, on understanding of content and memory for class activities and own learning experiences.

APPENDIX A.2 DETAILS OF THE FOUR STUDIES IN THE UNDERSTANDING LEARNING AND TEACHING PROJECT

Number of days	Number of target pupils	Age of pupils	Content of unit	Number of data intervals
			Study One	
31	3	9-10 years	Conservation, Erosion, and Endangered Animals	15,480 (1/2 mins)
			Study Two	
21	3	9-10 years	The Middle Ages in England	37,704 (1/4 mins)
			Study Three	
5	4	11 years	New York City: A Study of Cultural Differences	6,176 (1/4 mins)
			Study Four	
8	4	9-10 years	Weather: Observation and forecasting	6,784 (1/4 mins)

APPENDIX B: SAMPLE ITEM FILES

This Appendix contains a set of item files from Studies Three and Four. Each item file contains: the item, pupil responses to item in pre and post-tests, transcripts of each quarter minute interval that contains item relevant content, and a transcript of the item relevant segments of the post-test interviews.
The transcripts of each quarter minute interval contain:
Day and Time. Days are numbered 1-8, quarter minute intervals are numbered consecutively with in each day. For example, 2/136 refers to the 136th quarter minute interval on Day 2.
Code. The content category code for the item relevant content.
Pupil. Name of pupil(s) for whom the content is relevant
Context. Brief description of the activity and content context within which the content occurs
Transcript. Transcript of the spoken or written material relevant to the item
Behaviour. At the end of each quarter minute interval there is a copy of the recorded behaviours and private utterances occurring during the interval.

Appendix B.1 Item file for Item #6 Study Three

Item 6. Puerto Rica is
(a) the capital of Peru
(b) a Caribbean island
(c) a state of America
(d) an American port
(e) I don't know

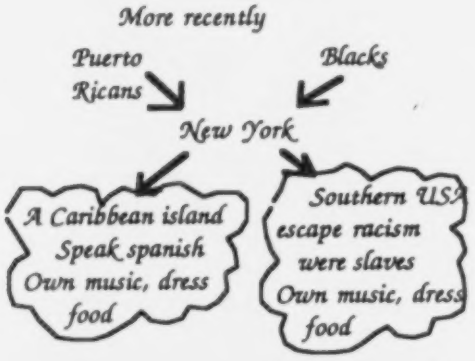
On pretest, Jon and Mia picked "the capital of Peru", Joe picked "I don't know" and Ann picked "an American port". Jon and Mia's response suggests they know something of Spanish-American names. Ann's may be based on the pronunciation of "Puerto" (the test was read aloud to them).

Day 1 Time 169 Code 8 (Jon only)
Context: Pupils set task to identify New York, Hudson river ,Atlantic Ocean, Mexico, etc. on blank printed map of North America)

Pupil: Atlantic ocean, Caribbean
Jon: Atlantic Ocean is here. Mexico. Mehico
Pupil: Mekico

(Jon talking to peer, looking at atlas, writing on sheet)

Day 2 Times 89,90 Codes 5, 1,7 (Jon, Joe, Ann, Mia)
Context: transparency containing the following diagram shown on screen



(Jon: watching teacher, watching screen, fiddling hands)
(Joe: chin on hands, calling out 'Caribbean, Caribbean')
(Ann: glancing around, swinging legs, talking to self: 'South America?'
(Mia: watching screen, talking to self: inaudible)

T: More recently the folk who have immigrated to N.Y. have come from mainly two different areas, one suburb being Puerto Ricans who came from Puerto Rica which is?
Pupil: Mexico
Pupil: The Caribbean
T: An island in the Caribbean. In Puerto Rica they speak Spanish, they have neat music

(Jon: watching screen, fiddling with hands)
(Joe: watching screen, talking to self: 'Caribbean')
(Ann: watching screen, swinging legs, talking to peer 'Puerto Ricans' . Oh, I put something different again.' Pupil: ' I put the (port?) of New York)
(Mia: watching screen, glancing down)

Day 3 Time 44 Code 7 (Jon, Joe, Ann, Mia)
Context: teacher has asked for children to nominate questions they would like answered about N.Y.)

Pupil: ... or something and where Puerto Rica was.

(Jon: glancing around)
(Joe: head on hands)
(Ann: smiling, watching teacher)
(Mia: watching teacher, glancing at camera operator)

Day 3 Time 81 Jon, Time 90 Joe, Time 82 Ann, Time 121 Mia Code 1
Context: Pupils have been set to read worksheet on 'Different nationalities and cultures'

(printed on sheet) ' ... Puerto Rica is a Caribbean island associated with the United States. When Puerto Ricans come to New York they bring their culture with them. ...'

(Jon: reading, turning pages)
(Joe: reading sheet, talking with peer 'I've got it. Immigrants ...Oh, yes, I was so. ... Drugs. Narcotics are drugs, dumbo')
(Ann: reading sheet, chin on hands)
(Mia: reading sheet)

Day 4 Time 22 Code 1 (Jon, Joe, Ann)
Context: Teacher is introducing children to a story about a Puerto Rican boy living in New York, whose name is Riki.

T: Where is Puerto Rica? Remember, one stage we mentioned it was an island, somewhere. Puerto Rica.
Pupil: Near Mexico in the Caribbean. To the right of that.
T: OK its just to the right of Mexico. The sea?
Pupil: The Caribbean
T: The Caribbean sea.

(Jon: to self: 'My cousin's called Ricky', watching teacher, fiddling with mouth)
(Joe: glancing at peer responding to T., fiddling with eye)
(Ann: watching teacher and blackboard)
(Mia is part of other group carrying out writing task, has desk raised, getting out pencils, doing art work)

Day 4 Times 30, 31 Codes 5, 10 (Jon, Joe, Ann, Mia)
Context: Teacher is summarizing black and Puerto Rican immigration to New York, draws outline map of N. America on blackboard and diagrams direction of migration

T: ...They went up to New York. And Puerto Rica. Which is an island here. (draws dot on blackboard map to mark location) Those folk came to New York. We're talking about a young boy, from Puerto Rica who lives in New York ...

(Jon: hand semi-raised, watches teacher, fiddling with knee)
(Joe: watching blackboard, head on hands)
(Ann: watching teacher, watching blackboard)
(Mia: is in other group, doing artwork on a picture of Statue of Liberty, recorded as overhearing the teacher's discussion)

Day 4 Times 194, 195, 196 Code 10 (Mia for 194,196, Jon for 196)
Context: Teacher is reviewing recent immigration to N.Y. and Story of Riki with a group which includes Mia but not other case study pupils. Other case study pupils are working on other individual task, but Jon appears to be listening

T: What country was Riki from? Some of you probably heard us say. Carol?
Pupil: Puerto Rica
T: He's a Puerto Rican boy which means he comes from Puerto Rica ...

(Jon: recorded as overhearing teacher talking to other group, chatting with peers: 'Maybe that's because its your folder' ..talking to self:. inaudible, doing artwork on folder)
(Joe: Reading and looking at pictures in book, chatting to peer 'I'm not going to read this' 'Hey, I've found another way' 'You have to follow the same route' 'Get nackered' 'Bom, bom, bo-oh', whistling.
(Ann: Colouring in picture, chatting and smiling with peers, 'I'm going to colour the whole thing round like this', looking at peer's work, singing to self.)
(Mia: raises hand, glances around, listening to pupil responding to teacher, comments to self 'Phew, he stinks')

Day 4 Time 200 Code 10 (Mia only)
Context: Teacher talking to group including Mia only)

T: ... and we said there were two more groups. One were folk who came from Puerto Rica. What was the other group, Micky?

(Mia: watching teacher, fiddling with nose, looking at map on blackboard)

Day 4 Time 202 Code 8 (Mia only)
Context: Teacher talking to Mia's group about black and Puerto Rican immigration to New York, referring to sketch map on blackboard

T: ... now there's no slavery. Some had moved to New York. They came from the island of Puerto Rica, there, to New York. ...

(Mia: looking at blackboard, half raises hand, smiling, fiddling with nose)

Long term interviews

Jon: I think it might be (b) ... oh because, um, in the study there was a lot of people who came from Puerto Rica who went to New York ...
I: Can you remember anything more being said about it in class?
Jon: Um ... I think it was that they were very poor there, and they wanted to come to New York 'coz America was like the, the, the greatest place on earth, like. ...

Joe: I think its an American port, because maybe in Mexican or something, Puerto means port and Rica means something ..
I: Oh. Does it? How did you learn that?
Joe: I didn't. I just guessed.
I: What does it bring to mind?
Joe: Its a small place and over-populated. Busy. ..
I: Why was it in the unit about New York? Why was there some discussion about Puerto Rica?
Joe: Because its probably near it.

Ann: Um, I put an American port, coz I can remember we had that story about the boy or something who came from Puerto Rica. And he was in those gangs and things. and he was on a port or something ... like that.

Mia: Um, a Caribbean island
I: Tell me how you remember that
Mia: Well, um, Mr. A. said lots of people came from, over from, from them and they speak Puerto Rican, and that's one of the languages that they (New Yorkers?) speak. Lots of languages in there. ... Its because they speak the different language, they come from a different place. So, you sort of think of it as two separate places.

Appendix B. 2 Item File for Item #28 Study Three Jon Only

Item 28. The population of New York is about
(a) 200,000
(b) 1 million
(c) 8 million
(d) 80 million
(e) I don't know

Test Results:		
	Pretest:	(e) I don't know
	Short term post-test	(c) 8 million
	Long term post-test	(a) 8 million

Day 1 Times 105, 106, 107, 108 Codes 7, 5, 1, 1
Context: Teacher is using map of North America, talks about the Hudson river as a route into farmland, and how New York grew as a consequence

T: Not going to cover a lot of how it grew tremendously except to say how big is it right now? And if you remember the question. We're talking about 1700, well 1600 right up to 1980 something. How big is big?
Pupil: A million people?
T: Think. Yes, it grew to a million people. It grew more than a million. I'll give you a figure.
Pupil: Eight million
T: What made you say 8 million?
Pupil: They were on our tests
T: In actual fact, right now the population of New York is somewhere between 8 and 9 million, so in actual fact, the answer is a brilliant one

(Jon: watching teacher, glancing at pupil talking, talking to self: "Eight million people", talking to peer: "The camera's on you", looking at map on screen, listening to peer (inaudible), talking to peer: "It's that big. Yes, it is that big, on the map. Man, you can fit New York on your face a few hundred times.")

Day 1 Time 125 Code 1
Context: Same as above. Teacher is talking about what is on a map of New York city

T: Anywhere I put those squiggly lines. Its all city. People live there. There are 9 million. ...

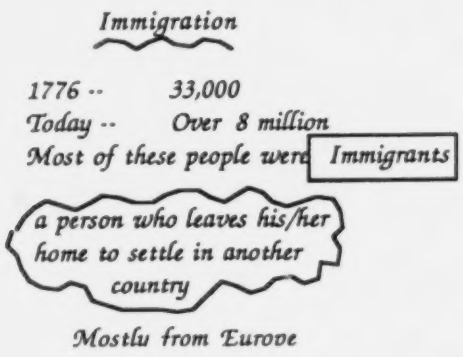
(Jon: looking at screen, fiddling with face, folding arms)

Day 2 Times 8, 9, 10 Codes 7, 1 1
Context: Teacher is reviewing with class yesterday's (Day 1) discussion

T: ... in those days it was a pretty big city. Today, David told us yesterday, about how many people live in New York? About?
Joe: Eight to nine million.
T: Eight to nine million, and it is still growing. There is one word that would indicate how New York grew so greatly and why it grew from a little wee place of about 33 thousand up to today, 8 or 9 million. ...

(Jon: watching teacher, glancing at peer, raising hand)

Day 2 Times 13, 14 Codes 2, 1
Context: Teacher projects transparency on to screen and is reviewing previous day's discussion of history and growth of New York


Immigration
1776 -- 33,000
Today -- Over 8 million
Most of these people were Immigrants
a person who leaves his/her home to settle in another country
Mostly from Europe

T: ... there were only 33,000 people there. Nowadays there are over 8 million, its 8 to 9, and most of these people are immigrants who came in.

(Jon: watching screen, yawns, watches teacher, glances around.)

Day 3 Time 74 Code 1
Context: Children are asked to read two page worksheet on immigration to the United States

Worksheet: When the United States was born in 1776 there were 33,000 people living in New York city. Today there are almost 8 million. Where did all the people come from?

(Jon: glancing down, fiddling with pencil case zip, reading silently)

Day 3 Time 95 Code 10
Context: Pupils are asked to write a list of Advantages and a list of Problems on a worksheet describing immigration to New York

Jon writes on worksheet, under his heading 'PROBLEMS', 'population growth', then crosses it out and writes 'language problems' etc.

(Jon: talking to peer: "What have you got Paul?", writing, listening to peer)

Day 5 Time 21 Code 7
Context: Teacher is introducing a task in which pupils are to identify whether items on a list of natural features, buildings, etc. exist in New York, Christchurch, neither or both.

T: (reading from list) Most people of European descent; population between 8 and 9 million; cosmopolitan nature of population; ...

(Jon: reading worksheet)

Day 5 Time 31 Code 1
Context: Same as above. Teacher is discussing how to do task. Seems to be responding to an inaudible pupil question about population

T: ... If you can, in pencil first. ... Yes I know it goes up. I've put between 8 and 9 million. The last figure I saw was just over nine, but the notes I gave you say 8 million, so I've got to be careful that I don't give you something that's entirely wrong ...

(Jon: reading, glancing at teacher, glancing at blackboard, whispering: "ooh, ... and ..(inaudible) .."

Day 5 Time 37 Code 3
Context: Pupils completing task as described above. Jon is going down list ticking for New York and Christchurch

(Jon: writing, reading, writing, glances at door as pupil goes out. Beside 'population between 8 and 9 million' on worksheet he ticks under New York and leaves a blank under Christchurch)

Day 5 Time 55 Code 7
Context: Same task as above. Teacher is circulating among groups answering questions. Jon and peers are discussing their answers together.

Jon: Hey what's an island 21 k's long. Is that Manhattan?
Pupil: Manhattan
Jon: It must be
Pupil: Most of European descent. That's both isn't it?
Pupil2: Mmm
Pupil: Population between 8 and 9.
Pupil2: Cosmopolitan?
Jon: Yeah, that's both

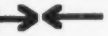
(Jon: writing, talking to peers, listening to teacher)

Long term Interview

Jon: Its got 8 million people.
I: You sound clear about that?
Jon: Yeah. I remember talking about that. and there's this programme on TV, um, yeah, um, I was sort of reading what its about. It said there are 8 million stories in the city, this is one of them. and I sort of clicked, aw, that 8 million people must be New York. I think its called 'Naked City', or something. And I think Mr. A actually taught us about, told us about 8 million people. .... I never actually watched it (TV programme) so I don't know what its about. Its on about midnight, I think.

Appendix B.3 Item File for Item #14 Study Four Rata only

Item 14. Which of the following shows a sign for a cold front?

(a) 

(b)

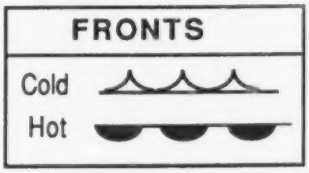
(c)

(d)

(e) I dont know

Test Responses:	Pretest:	(e). I don't know.
	Short term post-test	(c).
	Long term post-test	(c)

Day 4 Times 137,138 Codes 7,7,91
Context: Teacher hands out copies of two weather maps taken from local newspaper. Weather maps have the following in the legend beneath them:



T: Look at it carefully, they're labelled A and B. Let's have a look at them and I'm going to talk about them. Have a quick look at the two of them.

(Rata looking at map, talking to peer: "Its got 1010. 1010 and 1020" (referring to isobars on map))

Day 4 Time 153,154 Codes 1,2,6
Context: Teacher discussing with class what they can see on the weather maps.

T: Right, thank you. Yes, Norm?
Norm: There's a cold front going across Melbourne
T: What?
Norm: Cold front, yeah.
T: How do you know its a cold front?
Norm: Coz it says down the bottom
T: That thing with the lines and triangles on it
Rata: Yep
Pupil: Yep
T: It shows a cold front?
Rata: Yep.
Pupil: Like water.
T: Right

(Rata reading map, watching teacher, responding to teacher, fiddling with hair)

Day 4 Time 157 Codes 2, 10
Context: Teacher discussing with class differences between two weather maps from successive days

T: Dale, again?
Dale: Because its got different things on it like the H has moved and the L come onto it, and the cold front's on, its got more cold front, and all the arrows and lines have moved around a bit.
T: Oh. thank you.

(Rata reading map, fiddling with hair)

Day 4 Times 160-168 Code 7,9
Context: Teacher hands out three more weather maps which he calls E F and D. Pupils are asked to place them in order by analyzing the weather changes that are shown in them.

T: Oh here is a puzzle for you. We were talking a little bit about A and B, now we have E, F, and D. ... Cut these into three and then decide which is first, which is second, and which is third. If you can't, have a talk to your partner or your group. ... and once you've figured it out, I want to know the reason why you think that. ...

(Rata: listening to teacher, moves up to get maps and scissors. Talking to peer: 'I'll get you a pair, Sue. Here, Sue, you can use these after me', cuts map sheet to separate the three weather maps)

Day 4 Times 170-186 Codes 2,2,91
Context: Pupils are in groups of four trying to order the set of three weather maps.
(Relevant excerpts from Rata's group discussion and chatter)
Rata: Oh, you have to find out the days, eh?
Pupil: I can't find my 'E'
Rata: Let's see now. I reckon 'F' comes first. I think I've got it. No, I haven't.
Rata: I don't even know how you do it.
Rata: F, E, D.
Pupil: F, E, D
Rata: Fed. I can't.

(Rata: studying maps for 11 of the 16 intervals, glancing at teacher talking to other group, talking to peers, raises hand

---

Day 4 Times 187-203 Code 91
Context: Teacher explains and discusses with pupils how to tell which weather map goes first, second, third

T: If we look at D, E and F, two of them have got L's on them haven't they ..... etc.

(Rata: listening to teacher, reading weather maps, raising hand, glancing at pupil, fiddling with hair

---

Day 5 Times 113-116 Code 91
Context: Teacher discusses pupils' recording of weather outside classroom and relates their results to the weather maps they are looking at
T: Everyone please take out the sheet I gave you with the two maps on. Look at it very carefully, because I think a very funny thing has happened. Now, if we look at today's map and you look at the lines called isobars, ... etc.

(Rata: argues with peers about who's got the map. 'You had it. God, don't say he's lost it. Well, he had it on his desk. etc.' Looking at map. 'Is that it there?')

Day 6 Times 180-188 Code 91
Context: Teacher hands out a sheet with three weather maps photocopied onto it

T: OK I'm going to give you another piece of paper and ask you to tell me what pattern you can see. They're different from the other ones, so you don't need the other ones out. Right. What pattern can you see in these three maps?

(Rata: looking at maps, talking to peers:'What pattern? Starting from here? See, look at a pattern. It started off here first, on the coast and it came here first and its gone right round New Zealand. See, look, its pressure. The anticyclone starts off here. etc.)

Day 6 Times 196,197 Code 5,7
Context: Teacher asks pupils to say what patterns they see in the three weather maps.

Pupil: On the map of Saturday, its got a high and two lows and when you see on the other map its got no lows.
T: Right. Dale?
Dale: Well, on Saturday, you've got a big long cold front, and on the next one its a very little one, and on the third one, you've got another one on this side and in the same place as the first one was.
T: Thank you.

(Rata: reading map, talking to peer, writing)

Day 7 Times 221-240 Codes 2,1,2
Context: Teacher has handed out the weather map printed in local morning newspaper for the day, and asked pupils to try to forecast the next day's weather from it. Pupils are discussing their forecast in groups of four)

Rata: See, anticyclone high, its coming on to New Zealand.
Pupil: So there's an anticyclone.
Rata: Oh, god this is hard!
Pupil: There's a big cold front coming
Rata: Oh, god, there is too. Look there's a big cold front coming through Sydney. See, you can tell cold. See, that shape of it. ....
(further discussion about task requirements)
Rata: I reckon that big cold front will go away. I reckon that anticyclone will move somewhere else

(Rata: looking at weather maps, talking with peers)

Short Term Interview

Rata: .C.
I.You reckon, you're probably right, I'm not sure. You tell me how did you know that?
Rata:.It's on the weather. In the newspaper, I think it's that one
I:.Yes um, how did you know that?
Rata: .Mr B. It's got on the thing, um it's got cold, it's got something, it's got a cold front, it's got that pattern, it's got a bit, it says there, got something, one of those across the page and on the weather, ...
I:.Do you remember talking about that in class?
Rata:.Yes, it's on the weather map
I: How did he, did he show you a weather map?
R: He cuts, he cut them out of the newspaper, and he photocopied a whole lot and he gave them to us and then we talked about them
I: Right, and did you know about that before, or had you ever looked at weather maps before?
R: No we don't get the newspaper that much.

Appendix B.4 Item File for Item #14 Study Three Mia Only

Item 14. Compared with New Zealand, New York is considered to have
- a. a very low crime rate
- b. a low crime rate
- c. an average crime rate
- d. a high crime rate
- e. I don't know

Test results:		
	Pretest:	e. I don't know
	Short term post-test:	d. a high crime rate
	Long term post-test:	d. a high crime rate

Day 1 Times 15,22,23 Codes 5, 10, 10
Context: Teacher conducting brainstorm of ideas that are associated with New York.

T: Without thinking hard, what does the word New York make you think of?" ...
Pupil: Crime (T. writes 'crime' on list on OHP)

T: (reading from OHP) ..., crime, ...

(Mia: glancing round, hand semi-raised, watching OHP)

Day 1 Times 27, 41 Codes 5, 5
Context: Teacher conducting brainstorm of ideas about New York.

T: What do you actually know about New York as opposed to what it makes you think of? ...
Pupil: Yeah, lots of violence. ...
Pupil: You get mugged.

(Mia: glancing around, hand semi-raised)

Day 1 Times 153,157,169 Codes 6, 7, 10
Context: Pupils have been set group task of identifying and listing on an OHP the problems associated with living in a multiracial society. Pupils from a group not including Mia are reading from their OHP to rest of class.

Pupil: (reading from group OHP) ... crime, gangs ...

Pupil2: (reading from group OHP) ... gang fights ...

Pupil3: (reading from group OHP) ... violence, gangs ...

(Mia: watching OHP, rhythmical movement, fiddling with hair, giggling, head on hands)

Day 3 Times 161,173,174,175,176,265,286 Codes 6, 10, 10, 10, 10, 7, 8
Context: Teacher has set pupils the task of writing a five line poem (cinquain) about New York. He is writing a list of words on blackboard suggested by pupils to be used by them in writing poem: " muggers, ... shooting, ... violence ..."
(Mia: watching blackboard, watching teacher, fiddling with hair, smiling, glancing at observer, writing (her own poem), glancing at blackboard)

Day 3 Time 300 Code 6
Context: Pupil reads his poem to class

Pupil: "Violence, arrests, guns, canons, dynamite, shooting, massacre and gang killings."

(Mia: resting head on desk)

Day 4 Time 216, 227, 228, 231, 235 Codes 6, 6, 6, 6, 7
Context: Mia is reading story of Puerto Rican boy (Riki) living in New York.

Text: " ... he picked up a baseball bat at the edge of the court and hit his antagonist hard in the mouth, splitting both lips and seeing bits of broken teeth fall from the mouth in a mixture of heavy saliva and blood ... It was easy to get in with a gang of young hoodlums of your own kind and then to wage war on other gangs ... Not that they would likely kill another boy -- a sharp stab in the armpits of a boy pinned to the wall was agonizingly painful and partially crippling. ... "

(Mia: reading silently, fiddling with hair, glancing at teacher, talking to self: " ... Ooh, ... ooh,yuk ... ... unhygienic! ... "

Day 4 Time: 284, 285 Codes 7, 6
Context: Teacher asks pupils why Riki does what he does.

Mia: "Um, well his atmosphere, because lots, um, It said he belonged to a gang, so there would be all, most all the other people around him would probably be doing the same thing. so he felt compelled to do it."

Day 5 Times 42,51,88,95 Codes 7, 7, 7, 7
Context: Group including Mia is set the task of reading a list of 48 descriptions and deciding for each one whether it is true of New York and/or true of Christchurch. Two of the descriptions are "violence by gangs" and "gang warfare". Mia writes 'Yes' for New York beside each and 'No' for Christchurch beside each.
(Mia discusses some with peers, but no reference to these two was recorded. Later teacher discusses the answers to some in class, but did not discuss these two.)

Interview

Mia: A higher crime rate, crime rate with all the gangs and things happening, cause people don't have anything else to do.
Int: Did that come up in the unit?
Mia: Yes, a lot. Well, I think at one stage, which got me a bit confused, someone said that it had been in the paper that Christchurch had a a bigger, higher crime rate than New York, and I thought 'oh, no, that can't be right' ... ... Mm. Because you don't see gangs around, well people don't carry knives around in Christchurch. I wouldn't think so.

Appendix B.5 Item File for Item #45 Study Three Mia Only

Item 45. When an apartment building is 'condemned' this means that:

a. the police have put the owner in jail
b. the building is unsafe to live in
c. that people living in the building have not paid their rent
d. the building is going to be destroyed
e. I don't know.

Test Results:		
	Pretest:	e. I don't know
	Short term post-test	b. the building is unsafe to live in
	Long term post-test	b. the building is unsafe to live in

Day 1 Times 16,17,23 Codes 10, 10, 10
Context: Teacher asks pupils to list words that come to mind in association with New York. Teacher writes them on OHP.

Pupil: Apartment buildings
Teacher (reads OHP) ... apartment buildings, ...

(Mia: watching screen, glancing around, glancing at pupil)

Day 1 Time 287 Code 10
Context: Teacher is introducing a story he will read to pupils

T: I'm going to give you a small story I would like you to listen to. Its called 'Apartment Three'. (reads first part of story)

(Mia: hand semi-raised)

Day 2 Time 203, 204 Codes 10, 10
Context: Teacher is reading the second half of the story, 'Apartment Three'

T: 'Apartment Three'. Could I just complete this. I am going to go briefly over the last page before we stopped. ... (reads rest of story). ... they found it was Sam who, I think, comes from Apartment Three, ...

(Mia: head on hands, frowning, looking at picture in teacher's book)

Day 2 Time 255, 261,269 Codes 10, 10, 10
Context: Teacher is conducting class discussion of a man found dead in an apartment alone in New York.

Pupil: ".. if it was a kind of an apartment, well and he might ... "

Pupil: " ... and there aren't many apartment buildings in Christchurch "

Pupil: "... if he is in an apartment in Christchurch, or something, ... "

(Mia: glancing round, hand raised, rhythmical movement, head on hands)

Day 3 Times 20,22, 31,32 Codes 7, 8, 10, 10
Context: Teacher asks pupils to list things they want to know about New York. Teacher writes a list of the questions.

Mia: Different types of buildings of New York.
Teacher: ... there are a number of books here that would provide answers to that. ... just along the wall, some of these photos may well answer some of the questions, but, I'll see what I can find out about the buildings in New York.
Teacher: (reading list of questions asked) ... buildings in New York from Mia ...

(Mia: watching teacher, glancing at picture on wall, glancing at observer, glancing at peer, chewing)

Day 4 Time 220 Code 5 (subcode 21)
Context: Mia is reading story of Puerto Rican boy living in New York

Text: " ... Riki's home was on the 7th floor of an apartment building condemned in 1923. But it was still standing and occupied. In many of the apartments the toilets wouldn't flush properly, the drains from the kitchen sink failed to operate satisfactorily, it was a fire risk ... etc."

(Mia: reading, fiddling with hair, says to self "unhygienic!")

Day 5 Times 52, 53, 54, 55, 63 Codes 6, 6, 6, 6, 6
Context: Group of pupils, including Mia, is set the task of reading a list of 48 descriptions and deciding for each one whether it is true of New York and/or true of Christchurch. One of the descriptions is: 'people living in condemned tenement buildings'. Mia writes on her list 'Yes' for New York and 'Some times' for Christchurch.

(Mia: reading and writing on worksheet, talking with peers:
Peer: What does condemned mean?
Mia: Condemned. Its probably you are not allowed to live in it. .... Sophie, do you know what condemned means? (no audible reply).

Interview:

Mia: .. There was a story about an apartment building. Yes, it was condemned, I think, but people were still living in it.
Int: Right, so when it is condemned, what does that mean?
Mia: I think it means that the building is unsafe to live in. I am not sure whether it is going to be destroyed or not.
Int: Can you remember the story?
Mia: Not really. It was about a boy who was living within this condemned building and you could hear everything they were saying through the walls ... etc.

Appendix B.6 Item file for Item #57 Study Three Jon only

Item 57 A tenement is
a. an ointment used with racehorses
b. a building where people live
c. a trolley car
d. a ten-pin bowling alley
e. I don't know

Test Responses:		
	Pretest:	a. an ointment used with racehorses
	Short term post-test	b. a building where people live
	Long term post-test	b. a building where people live

Day 1 Times 16.17.23 Codes 10,10,10
Context: Class discussion of ideas about New York, pupils listing ideas, teaching writing them on overhead transparency

Pupil: Big buildings
Pupil: Apartment buildings
T: ... big buildings, ... apartment buildings, ...

(Jon: watching screen, talking to peer "they're big buildings", glancing at observer, watching teacher

---

Day 1 Time 297 Code 5 (subcode 21)
Context: Teacher is introducing story which he is to read to class. Title is *Apartment Three*.

T: .. if I said that there's one thing in this picture that makes you think that its a poor tenement type building, there's something in there just so you pick that up ...

(Jon: watching book held up by teacher, fiddling with knee)

Day 2 Time 236 Code 5 (subcode 21)
Context: Class discussing a man found dead in his room in New York

Pupil: The neighbours
T: The neighbours. There must have been somebody next door. It was in a tenement building.

(Jon: Watching teacher, calling out to teacher: "For two years", fiddling with teeth)

Day 3 Times 20, 22, 32 Codes 10, 10, 10
Context: Teacher asks class to list things they would like to know about in New York.

Pupil: Different types of buildings in New York
T: Somebody asked about slums in Harlem and living conditions ... buildings in New York ...

(Jon: glancing round, glancing at observer, talking to self: " That's Hudson, jerk. Oh, gawd!"

Day 4 Times 47 Code 5 (subcode 21)
Context: Pupils reading story of Puerto Rican boy, Riki.

Text of Story: Riki's home was on the 7th floor of an apartment building condemned in 1923. ... Even the wallboards separating each apartment in this old tenement might have been made of paper. ...

(Jon: reading story, fiddling, talking to self "ugh!"

Day 4 Time 74 Code 5 (subcode 21)
Context: Teacher is discussing the meaning of words in the story with the pupils.

T: (reading story aloud) Even the wallboards separating each apartment in this old tenement might have been made of paper. ...

(Jon: reading story, watching teacher, hand raised)

Day 5 Times 28, 48 Codes 5 (subcode 21), 7
Context: Group of pupils, including Jon, is set the task of reading a list of 48 descriptions and deciding for each one whether it is true of New York and/or true of Christchurch. One of the descriptions is: 'people living in condemned tenement buildings'. Jon writes on
his list 'Yes' for New York and 'No' for Christchurch.

T: (reading list to class) ... large tenement buildings ...

(Jon: listening to teacher, reading sheet, writing answers on sheet, laughing)

No interview on this item

APPENDIX C. THE CODING OF TYPES OF CONTENT

Code 1. *Explicit Spoken:* Item answer or paraphrase of item answer spoken.

1.1 Exact item answer: provides answer, wording close to test item

1.2 Approximate item answer: paraphrase or almost complete answer to test item

1.3 Full item answer given which is believed to be correct but is in fact incorrect (Validity coded as 4. Incorrect statement)

Code 2. *Explicit Visual:* Item answer or equivalent presented visually or by demonstration, drawing or colouring activity.

6.3 Drawing, diagram, illustration containing information directly relevant to item answer.

6.5 Colouring, drawing to specifications provided by teacher, filling in maze, when the activity involves information directly relevant to item answer

8.1 Directly relevant display or visual resource: visual resource being attended to which provides directly relevant information.

8.3 Directly relevant demonstration: a demonstration is being attended to which provides directly relevant information

Code 3. *Explicit Procedural:* Item answer procedure carried out or practiced, or instructions given for carrying out item answer procedure.

6.1 Procedural experience: carrying out the same procedure as that required to answer item using the same equipment as that used in the item (e.g. a thermometer). Conducting an experiment designed to give information required to answer item.

7.1 Guided practice: teacher provides instruction or guided practice for activity required to answer item.

7.2 Procedural instructions: instruction in how to carry out a procedure which produces information or experience relevant to an item answer.

Code 4. *Explicit Written:* Item answer or paraphrase of item answer written or copied.

6.7 Pupil writing or worksheet generated writing or responses (e.g. ticking) when the content is directly relevant to item answer.

6.9 Pupil copying work straight from blackboard to own worksheet - information sufficient to answer item

6.91 Ditto but only part of information needed to answer item.

6.92 Copied use of key word but no additional information

Code 5. *Partial Item Information:* Part of an item answer or information from which it is possible to deduce item answer.

2.1 Logical implication: statements from which answer can be logically inferred.

2.2 Associated answer elements: statements which contain the elements of an answer - but .pupil needs to make the logical connections in order to find out the item answer..

2.3 Partial answer: statements which contain significant parts of the answer but not the whole answer.

2.4 Statement about what is NOT the answer, or what the answer is NOT

Code 6. *Reasons and examples:* examples, instances, analogies, underlying processes, explanations.

3.3 Reasons and explanations: identification of underlying processes, explanations, or reasons.

3.4 Analogies and examples: statements about relationships with other ideas, concepts; or illustrative examples. Negative instances.

3.5 Pupil personal experience: related out-of-class pupil personal experience.

Code 7. *Verbal Background and Related Information:* Additional, contextual and background information related to item answer, including pupil personal experiences.

3.1 Background information: descriptions, definitions, spelling etc.,of key words,concepts in the item answer.

3.2 Additional related information: additional information, logically related to answer.

4.1 Statement of intention, attention focussing: identification of what is about to be discussed, what should be done by pupils. Review of what has been said before -- without specific item relevant information.

4.2 Narrative context: identification of events leading up to and away from the item answer.

4.3 Discussion context: discussion leading up to an item answer. (15 second interval in which the discussion is leading up to an item answer, or item related content. Normally the discussion will have been started by a teacher question (or implied question) which frames the discussion and leads to an answer in a subsequent

15 second interval)

4.4 Question: a question relevant to an item is asked, or printed, but the answer is not supplied.

6.8 Pupil writing or worksheet generated writing or responses when the content provides background or indirectly relevant information

Code 8. *Visual Background Information:* Additional, contextual or explanatory information related to item answer, presented visually or by drawing or colouring.

6.4 Indirectly relevant diagram, illustration, drawing containing background information, context, explanation, etc.

6.6. Indirectly relevant colouring, drawing to specifications, etc. Information contained in the activity is background or indirectly relevant.

8.2 Indirectly relevant display or visual resource: visual resource provides background information, conceptual context or explanation.

8.4 Indirectly relevant demonstration: a demonstration is being attended to which provides background information, conceptual context or explanation.

Code 9. *Procedural Background Information:* Additional or indirectly related information about item-relevant procedures, or review of item-relevant procedures.

6.2 Procedural experience or activity which provides indirectly relevant information. When other equipment, apparatus is used to demonstrate working of equipment in item e.g. balloons used to show working of barometer.

7.3 Instruction for related activities: instruction for procedures, activities which are peripherally related.

7.4 Reviewing an activity or procedure: discussing, reporting,reviewing an activity after completing it.

Code 10. *Occurrence of Key Word or Concept:* Reference made to key word or concept in context which does not contain item-relevant information. (51,52,53)

5.1 Spoken use of key words: a key word in item answer occurs in discussion or without conveying information relevant or related to answering item information. (e.g. brainstorm listing)

5.2 Printed, written use of key word, read but not mentioned, or written by pupil

5.3 Visual portrayal of key word or concept in pupil work (drawing, illustration)

Code 91. *Peripheral Resource:* Item answer or part of item answer visually present (e.g. on blackboard, wall map) but not explicitly attended to.

9.1 Peripheral resources: item answer information is visible or available in materials, resources around or in front of pupils, but is not explicitly referred to, or pointed to.

9.2 As above, but the information is only part of the item answer.

APPENDIX D

RULES FOR PREDICTING LEARNING OUTCOMES FROM THE INFORMATION STREAM

The ability to answer a test question is based on the existence in memory of a schema containing the information needed to answer the question.

Information obtained from classroom experience is initially held in a temporary memory store until either:
a. sufficient information is accumulated to form the basis for a schema and it is transferred as a schema to permanent memory, or
b. it fades from the temporary store.

Types of Item Content

The types of accumulated information needed to form an appropriate schema vary according to the type of item. Four types of item have been distinguished:

1. Word Meaning: Items about the meaning of words, e.g. What does 'ethnic' mean? What does 'despondent' mean?

2. General Concepts: Items involving general or abstract concepts where the answer can be inferred from examples or instances, e.g. Compared to New Zealand, New York is considered to have? a high crime rate. New York is made up of? people of many races.

3. Visual: Items involving significant visual content, e.g. Mark New York on the map of the world. Manhattan is a similar shape to? a shoe.

4. Specific information: Items which ask for the recall of events, facts (e.g. The population of New York is? 8 million), names (e.g. What area is known as the heart of New York? Manhattan), and descriptions (e.g. Broadway is? the longest street in New York).

5. Skill Items: The item asks for the pupil to perform a skill or carry out a procedure, e.g. Write down the temperature shown on this thermometer.

Adding Information the the Temporary Store

All information whose content is coded as 1, 2, 3 , 4, 5 (See Appendix C) gets added, as it is experienced, to the temporary store. It drops out from the temporary store unless, within a specified period of time, further relevant information gets added. Once an appropriate cluster of item-

relevant information is accumulated in the temporary store, an item schema is formed. This is transferred to memory and all subsequent item-relevant information gets added to it in memory.

Evaluating the Content of the Temporary Store

The evaluation rules which determine when the information in the temporary store is transferred as a schema to memory are as follows:

1. Transfer of Information as Schema from Temporary Store to Memory.

A. For all items: Information is transferred to memory as a schema when it consists of either:

1.1. Code 1 or 4 information plus two different instances of Code 5 or Code 6 information, or
1.2. Two different instances of Code 1 or 4 information plus Code 5 or Code 6 information
1.3. Three or more different instances of Code 1 or 4 information

Note: For Study Four pupils, the above rules are modified to include an additional instance of Code 1 or 4 information in Rules 1.1 and 1.3, and an additional instance of Code 5 or 6 information in Rule 1.2

B. Word Meaning Items: Additional rules are added top cover the situation where word meanings are inferred from experiencing them in an informative context. These are:

1.4 Code 1 or 4 information plus an instance of an activity or discussion involving the use of the word, i.e. Code 7, sub-code 68 or 43
1.5 Two or more different instances of the word occurring in a context from which it is possible to infer the meaning, i.e. Code 5 subcode 21

C. Visual Items: For visual items, the rules are altered to include the necessity for information with visual content. Rules 1.1, 1.2, 1.3 are altered to require an instance of Code 2 information instead an instance of Code 5 or Code 6 information.

D. General Concept Items: For these items a further rule is added to cover situations where the answer to a general concept item is inferred from a sequence of partial answers or examples of the concept. This rule is:

1.6 Four or more different instances of Code 5 or Code 6 information.

2. Retaining Information in Temporary Store.

2.1. Code 1 or 4 information is held for the day on which it is experienced and is then deleted unless
- 2.1.1. a further instance of Code 1 or 4 information is added on the same or the next day
- 2.1.2. Code 5 or Code 6 information is added on the same or the next day
- 2.1.3. there is already Code 5 or Code 6 information in the Temporary Store

2.2 Code 2 information is held for the day on which it is experienced and is then deleted unless
- 2.2.1 There is already Code 1 (or 4) information in the Temporary Store
- 2.2.2. There are already three instances of Codes 2 or 5 or 6 information in the Temporary Store
- 2.2.2 Code 1 (or 4) information is added on the same day

2.3. Code 5 and Code 6 information is held for the day on which it is experienced and is then deleted unless
- 2.3.1. there is already Code 1 or 4 information in the Temporary Store
- 2.3.2. Code 1 or 4 information is added on the same day.
- 2.3.3. there are already two instances of Code 2 or Code 5 or Code 6 information in the Temporary Store
- 2.3.4 two further instances of Code 2 or Code 5 or Code 6 information are added on the same day

2.4 Code 7 or 8 information is held for the day in which it is experienced and is then deleted unless
- 2.4.1 there is already Code 1 or 4 information in the Temporary Store
- 2.4.2. Code 1 or 4 information is added on the same day.
- 2.4.3. two instances of Code 2 or 5 or Code 6 or 8 are added on the same day.

If these conditions are met, the Code 7 or 8 information is added to the contents of the Temporary store and transferred with them to memory.

Adding information to schema in memory

Once a schema is formed in memory, all further item relevant information is added directly to that schema. Although it is not apparently needed to predict learning outcomes, the following rule defines this process.

3.1 All item-relevant information occurring in intervals following the formation of a schema is attached directly to that schema in memory.

APPENDIX E. FUNCTIONAL CLASSIFICATION OF PUPIL BEHAVIOURS

1. Task Appropriate Behaviours
   behaviours that conform to the requirements of the task or context, e.g. reading when the task requires pupil to read worksheet

   1.1 Informative Behaviours
   appropriate behaviours when cognitive processing is not evident, e.g. watching teacher, watching screen when these are sources of relevant information

   1.2 Active Cognitive Processing
   appropriate behaviours when there is evidence that information is being attended to or processed

   1.21 Expressive
   behaviour which indicates that cognitive processing is occurring, e.g. expresses involvement (raises hand), knowledge (states answer), puzzlement (questions, erasing)

   1.22 Productive
   behaviour which provides information or the practice/use of knowledge, e.g. reading, writing, using equipment, asking for information

2. Task Feeling Behaviours
   behaviours which indicate that task or activity is interesting, boring, difficult, etc.

3. Neutral Behaviours[1]
   behaviours involving body movements, facial expression, which do not appear to be related to cognitive processing in this context.

4. Organizational Behaviours
   behaviours that involve preparing for or organizing tasks, clarifying task requirements, etc, where the task is one that produces item-relevant information.

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[1] The difference between neutral behaviours and 1.21. expressive behaviours is something which needs to be determined empirically for each child. Presumptions about what these potentially expressive behaviours might mean cannot be determined with systematic analysis of how and where they occur for each child.

5. Alternative Behaviours
   behaviours that are appropriate to another task or context other than the one that is the source of item-relevant information

   5.1 Informative Behaviours
   behaviours which indicate attention to sources of information other than the item-relevant sources

   5.2 Active Cognitive Processing
   behaviours which indicate active involvement with content other than item-relevant content

6. Negative Behaviours
   behaviours which indicate that attention is focussed on something other than relevant classroom information or activities

APPENDIX F. VALIDITY CODING CATEGORIES

1. *Valid statement(s)*: content clearly true and appropriate to correct test item answer. or concept

2. *Ambiguous or mixed statement(s)*: mixture of true and false information, or statements which are ambiguous or unclear.

3. *Corrected statement(s)*: statements or discussion containing wrong or ambiguous elements but teacher (or O. P.) attempts to correct or clarify.

4. *Incorrect statement(s)*: statements or discussion containing incorrect information only. Also information which is very misleading or garbled. Information which is potentially confusing.

5. *Analogy or synonym*: the statement involves an analogy or word closely associated with a key word or concept. The link with the key word or concept is not explicitly made in the same statement.
   Information given is part of a subset of the key concept, or there is indirect reference to the key word or concept.
   A piece of equipment is being demonstrated but is not named.

6. *Irrelevant*: What is said is about procedures or about what is about to be said or done
   (Used with Content codes 71,72,73,41,42, and with 51 and 52 when the mention is clearly irrelevant to item.)